

NUMBER (Series of 1925)

1655113
1921 PATENT NO.

1928

DATED

DIV. _____

EX'R'S BOOK) _____

07-094-07135

Name Nikola Tesla

of _____

State of _____

Invention _____

ORIGINAL

RENEWED

APPLICATION FILED COMPLETE _____, 1928

Petition, Specification,
Oath, First Fee \$20, } _____, 1928
_____ sheets Drawings, }

Examined and passed for Issue _____, 192

Exr. Div. _____

Notice of Allowance _____, 192

By Commissioner.

Final Fee _____, 192

Attorney _____

Associate Attorney _____

No. of Claims Allowed _____ Print Claims _____ in O. G. Class _____

Title as Allowed _____



421

X

1928
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NUMBER (Series of 1915);

1921

(EX'R'S BOOK)

1655113

65-21

DIV.

22

PATENT No.

1655113

Name

Nikola Tesla.

JAN 3 1928

of

County of

State of

Invention

New York.

New York.

Method of Aerial Transportation

ORIGINAL

RENEWED

Petition Sept 9, 1921

Affidavit " " 1921

Specification " " 1921

Drawing " " 1921

Photo Copy " 1921

First Fee Cash \$15 Sept 9, 1921

" " Cert. " 1921

Appl. filed complete Sept. 9, 1921

Examined and Passed for Issue

Oct 7, 1921

Exr. Div. 22

Notice of Allowance OCT 12 1921

By Commissioner.

Final Fee Cash \$20 Dec 7, 1921

" " Cert. " 1921

Patented

Attorney

Kerr, Page, Cooper & Hayward

Copper, Herr & Munroe

Associate Attorney

John P. Tarbox

502 So. Eringer Place

Philadelphia, Pa.

(No. of Claims Allowed 4)

Print Claims

Claim 1

in O. G.

(Cl. 244-14)

Title as Allowed

Method of Aerial Transportation.

Great Britain April 1, 1921

MZ

1921

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LAW OFFICES OF
COOPER, KERR & DUNHAM

42 BROADWAY,
NEW YORK CITY.



February 18, 1926.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

We enclose herewith check to your order for
\$10.00 to be applied in payment of appeal
fee in the application for Letters Patent named below:

Nikola Tesla,

Serial No. 499,519,

Filed September 9, 1921,

Method of Aerial Transportation.

In case the above is for the payment of a First
please make three copies of the drawings in the
place one copy in the file and send two
ing same to our deposit account.

Respectfully,

Cooper, Kerr & Dunham,

D.

OK
J.H. Colwell
Per MR

See memo for Pat in file

Div. 27

These are not
first full cases
& prints are not
ordered.

Div. 6 -
all

15 REC'D
SEP 16 1921
U.S. PAT. OFFICE

499,519

IV. XILL. PAPER No. 1

SEP 16 1921

U.S. PATENT OFFICE

9406

Petition.

To the Commissioner of Patents:

Your petitioner Nikola Tesla, a citizen of the United States,

residing at New York, in the County and
State of New York,

Post Office address 8 West 40th St., New York, N. Y.,

prays that Letters Patent may be granted to him for the new and
useful improvements in

Method of Aerial Transportation.

set forth in the annexed specification;

And he hereby appoints Kerr, Page, Cooper & Hayward
(a firm composed of Thomas B. Kerr, Parker W. Page, Drury W. Cooper,
John C. Kerr, Jonathan B. Hayward and Sturges S. Dunham, Reg. No.
8894), of No. 55 Liberty Street, New York, N. Y., his attorneys,
with full power of substitution and revocation, to prosecute this application,
to make alterations and amendments therein, to sign the drawings, to receive
the patent, and to transact all business in the Patent Office connected there-
with.

Inventor's full name here: {

Nikola Tesla



Specification.

To all whom it may concern:

Be it known that I, Nikola Tesla, being a citizen of the
United States,

residing at New York, in the County and
State of New York,

have invented certain new and useful improvements in

Method of Aerial Transportation.

of which the following is a full,
clear, and exact description.

~~METHOD OF AERIAL TRANSPORTATION.~~

~~Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city county and State of New York, have invented a new and useful Method of Aerial Transportation of which the following is a specification.~~

me

The utility of the aeroplane as a means of transport is materially lessened and its commercial introduction greatly hampered owing to the inherent inability of the mechanism to readily rise and alight, which is an unavoidable consequence of the fact that the required lifting force can only be produced by a more or less rapid translatory movement of the planes or foils. In actual experience the minimum speed for ascension and landing is a considerable fraction of that in full flight, and the principles of design do not admit of a very great advance in this respect without sacrifice of some desirable feature. For this reason planes of very large area, high lift wing-sections, deflectors of the slip-stream of the propeller, or analogous means, which might be helpful in these operations, do not afford the remedy sought. This indispensable high velocity, imperilling life and property, makes it necessary to equip the machine with special appliances and provide suitable facilities at the terminals of the route, all of which entail numerous drawbacks and difficulties of a serious nature. So imperative has it become to devise some plan of doing away with these limitations of the aeroplane that the consensus of expert opinion characterizes the problem as one of the most pressing and important and its practical

solution is eagerly awaited by those engaged in the development of the art, as well as the general public.

Many attempts have been made to this end, mostly based on the use of independent devices for the express purpose of facilitating and insuring the start and finish of the aerial journey, but the operativeness of the arrangements proposed is not conclusively demonstrated and, besides, they are objectionable, constructively or otherwise, to such an extent that builders of commercial apparatus have so far not considered them of sufficient value to depart from present practice.

More recently, professional attention has been turned to the helicopter which is devoid of planes as distinct organs of support and, presumably, enables both vertical and horizontal propulsion to be satisfactorily accomplished through the instrumentality of the propeller alone. However, although this idea is quite old and not a few experts have endeavored to carry it out in various ways, no success has as yet been achieved. Evidently, this is due to the inadequacy of the engines employed and, perhaps, also to certain heretofore unsuspected characteristics of the device and fallacies in the accepted theory of its operation, an ^{c d}elucidation of which is deemed necessary for the clear understanding of the subject.

The prospects of a flying machine of this kind appear at first attractive, primarily because it makes possible the carrying of great loads with a relatively small expenditure of energy. This follows directly from the fundamental laws of fluid propulsion, laid down by W. T. M. Rankine more than

fifty years ago, in conformity with which the thrust is equal to the integral sum of the products of the masses and velocities of the projected air particles; symbolically expressed,

$$T = \sum (mv).$$

On the other hand, the kinetic energy of the air set in motion is

$$E = \sum \left(\frac{1}{2} mv^2 \right).$$

From these equations is it evident that a great thrust can be obtained with a comparatively small amount of power simply by increasing the aggregate mass of the particles and reducing their velocities. Taking a special case for illustration, if the thrust under given conditions be ten pounds per horsepower, then a hundredfold increase of the mass of air, accompanied by a reduction of its effective velocity to one-tenth, would produce a force of one hundred pounds per horsepower.

But the seemingly great gain thus secured is of little significance in aviation, for the reason that a high speed of travel is generally an essential requirement which can not be fulfilled except by propelling the air at high velocity, and that obviously implies a relatively small thrust.

Another quality commonly attributed to the helicopter is great stability, this being, apparently, a logical inference judging from the location of the centers of gravity and pressure. It will be found, though, that contrary to this prevailing opinion the device, while moving in any direction other than up or down, is in an equilibrium easily disturbed and has, moreover, a pronounced tendency to oscillate. It is true, of course, that when the axis of the propeller is

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vertical and the ambient air quiescent the machine is stable to a degree, but if it is tilted even slightly, or if the medium becomes agitated, such is no longer the case.

In explanation of this and other peculiarities, assume the helicopter poised in still air at a certain height, the axial thrust T just equalling the weight, and let the axis of the propeller be inclined to form an angle α with the horizontal. ^{pitch angle} The change to the new position will have a twofold effect: the vertical thrust will be diminished to

$$T_v = T \sin \alpha,$$

and at the same time there will be produced a horizontal thrust

$$T_h = T \cos \alpha.$$

Under the action of the unbalanced force of gravity the machine will now fall along a curve to a level below and if the inclination of the propeller as well as its speed of rotation remain unaltered during the descent, the forces T , T_v and T_h will continuously increase in proportion to the density of the air until the vertical component T_v of the axial thrust T becomes equal to the gravitational attraction. The extent of the drop will be governed by the inclination of the propeller axis and for a given angle it will be, theoretically, the same no matter at what altitude the events take place. To get an idea of its magnitude suppose the elevations of the upper and lower strata measured from sea level be h_1 and h_2 , respectively, d_1 and d_2 the corresponding air densities and $H=26700$ feet the height of the "uniform atmosphere", then as a consequence of

Boyle's law the relation will exist

$$\frac{h_1 - h_2}{1} = H \log \frac{d_2}{d_1}$$

It is evident that

$$\frac{T}{T_1} = \frac{T}{T \sin \alpha} = \frac{1}{\sin \alpha} \text{ must be equal to } \frac{d_2}{d_1} \text{ in order that}$$

the vertical component of the axial thrust in the lower stratum should just support the weight. Hence

$$\frac{h_1 - h_2}{1} = H \log \frac{1}{\sin \alpha}$$

Taking, in a special case, the angle $\alpha = 60^\circ$, then $\frac{1}{\sin \alpha} = \frac{1}{0.866} = 1.1547$

and

$$h_1 - h_2 = 26700 \times \log_e 1.1547 = 3840 \text{ feet.}$$

In reality the drop will be much greater for the machine, upon reaching the lower layer with a high velocity relative to the medium, will be urged further down along the curved path and the kinetic energy, in the vertical sense, possessed by the moving mass must be annihilated before the fall is arrested in a still denser air stratum. At this point the upward thrust will be far in excess of the opposed pull of the weight and the apparatus will rise with first increasing and then diminishing speed to a height which may approximate the original. From there it will again fall and so on, these operations being repeated during the forward flight, the up and down excursions from the main horizontal line gradually diminishing in magnitude. After a lapse of time, determined by numerous influences, the excursions should cease altogether and the path described become rectilinear. But this is next to impossible as can be readily shown by pointing out another

curious feature of the helicopter.

In the foregoing the axis of the propeller was supposed to move always parallel to itself, which result might be accomplished by the use of an adjustable aileron. In this connection it may be pointed out, however, that such a device will not act in the manner of a rudder, coming into full play at intervals only and performing its functions economically, but will steadily absorb energy, thus occasioning a considerable waste of motive power and adding another to the many disadvantages of the helicopter.

Let now the machine be possessed of a certain degree of freedom, as will be the case normally, and observe in the first place that the blades of the propeller themselves constitute planes developing a reaction thrust, the pressure on the lower leading blade being greater than that exerted on the higher one owing to the compression of the air by the body of the machine and increased density in that region. This thrust, tending to diminish the angle α ^{alpha}, will obviously vary during one revolution, being maximum in a position when the line of symmetry of the two propeller blades and that of flight are in a vertical plane and minimum at right angles to it. Nevertheless, when the horizontal speed is great it may be considerable and sufficient to quickly overcome the inertia and gyroscopic resistances all the more readily as the upper blade, which is situated in a region where the conditions are more nearly normal, operates to the same effect. Moreover, this disturbing effect partakes of the regenerative quality, the force increasing as the angle diminishes up to a maximum

for $\alpha = 45^\circ$. As the axis is tilted more and more, the vertical sustaining effort of the propeller will correspondingly diminish and the machine will fall with a rapidly increasing velocity, finally exceeding the horizontal when the reaction of the blades will be directed upward so as to increase the angle α and thereby cause the machine to soar higher. Thus periodic oscillations, accompanied by ascents and descents, will be set up which may well be magnified to an extent such as to bring about a complete overturn and plunge to earth.

It is held by some experts that the helicopter, because of its smaller body resistance, would be capable of a higher speed than the aeroplane. But this is an erroneous conclusion, contrary to the laws of propulsion. It must be borne in mind that in the former type, the motive power being the same, a greater mass of air must be set in motion with a velocity smaller than in the latter, consequently it must be inferior in speed. But even if the air were propelled in the direction of the axis of the screw with the same speed V in both of them, while the aeroplane can approximate the same, the helicopter could never exceed the horizontal component $V \cos \alpha$ which, under the theoretically most economical conditions of operation, would only be $0.7 V$, and this would be true no matter how much its resistance is reduced.

Another very serious defect of this kind of flying machine, from the practical point of view, is found in its inability of supporting itself in the air in case of failure of the motor, the projected area of the propeller blades being inadequate for reducing the speed of the fall sufficiently to avoid disaster, and this is an almost fatal impediment to its commercial use.

From the preceding facts, which are ignored in the technical publications on the subject, it will be clear that the successful solution of the problem is in a different direction.

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My invention meets the present necessity in a simple manner without radical departure in construction and sacrifice of valuable features, incidentally securing advantages which should prove very beneficial in the further development of the art. Broadly expressed, it consists in a novel method of transporting bodies through the air according to which the machine is raised and lowered solely by the propeller and sustained in lateral flight by planes. To accomplish this a light and powerful primemover is necessary and as particularly suited for the purpose I employ, preferably, a turbine of the kind described in my U. S. Patent No. 1,061,206, of May 6, 1913, which not only fulfills these requirements, but is especially adapted to operation at high temperature. I also make arrangements whereby the flying machine may be, automatically or at will of the operator, caused to function either as a helicopter or an aeroplane.

Full knowledge of these improvements will be readily gained by reference to the accompanying drawings in which Fig. 1 illustrates the machine in the starting or landing position and Fig. 2, in horizontal flight. Fig. 3 is a plan view of the same with the upper plane partly broken away.

The structure is composed of two planes or foils 1, 1 rigidly joined. Their length and distance apart may be such as to form a near-square for the sake of smallness and

compactness. With the same object the tail is omitted or, if used, it is retractable. The motors 2,2 in this case turbines of the kind described in my patent before referred to, and other parts of the motive apparatus are placed with due regard to the centers of gravity and pressure and the usual controlling means are provided. In addition to these any of the known stabilizing devices may be embodied in the machine. At rest the planes are vertical, or nearly so, and likewise the shaft driving the propeller 3, which is constructed of a strength, size and pitch that will enable it to raise the entire weight with the motors running at an even greater rate than when propelling the machine horizontally. Power is transmitted to the shaft from the turbines through suitable gears. The seats 4,4,4 for the operator and passengers are suspended on trunnions 5,5 on which they can turn through an angle of about 90° , springs and cushions (not shown) being employed to insure and limit their motion through this angle. The usual devices for lateral and directional control, 6,6 7,7 and 8,8 are provided with mechanical connections enabling the operator to actuate the devices by hand or foot from his seat in any position. At the start, sufficient power being turned on by suitable means, also within his reach, the machine rises vertically in the air to the desired height when it is gradually tilted by manipulating the elevator devices and proceeds like an aeroplane, the load being transferred from the propeller to the foils as the angle of inclination diminishes and the speed in horizontal direction increases. ¹⁹ In descending, the forward speed is reduced and the machine righted again,

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A3

acting as a helicopter with the propeller supporting all the load. ⁽¹³⁾ The type of turbine used is a motor of great lightness and activity and lends itself exceptionally to this kind of work for which ordinary aviation motors are unsuited. It is capable of carrying a great overload and running without danger at excessive speed so that during the starting and landing operations the necessary power can be developed by the motors even though less efficiently than under their normal working conditions. Special means of control may be provided, if necessary, for increasing the power supply in these operations. Owing to its extreme simplicity the motive apparatus is very reliable in operation, but should the power give out accidentally, landing can still be easily effected by volplaning. For this purpose, in addition to wheels 9,9 and 10,10 wheels 11,11 are employed, the latter being mounted on the forward end under the lower plane and so that when the machine rests on level ground the propeller shaft will have the desired inclination which is deemed best for rising in the manner of an aeroplane. Such ^{an aeroplane} ~~a helicopter-plane~~ constructed and operated as described, unites the advantages of both types and seems to meet best the requirements of a small, compact, exceedingly speedy and yet very safe machine for commercial use. Especially good practical results are obtainable by the use of my turbine which can be depended upon to develop the necessary energy for lifting, even if it should be considerably greater than that consumed ~~in flight~~ under normal conditions. This end can be conveniently attained by tempor-

Per A

arily supplying more of the working fluid to the rotor and driving it faster, or running it at about the same speed and increasing the effort by adjustment of the pitch of the propeller, ^{or other means known in the art.} The latter should be designed to work most economically during the flight, as its efficiency in the starting and landing operations is of relatively small importance. Instead of a single large screw as described a number of smaller ones may be used, in which case gearing can be dispensed with. The biplane seems to be best suited for the chief purpose contemplated but the invention is applicable to monoplanes and other types.

Insert A⁴ 21 I do not claim herein the apparatus by means of which this method is or may be carried out either in the special form illustrated or in modifications of the same, as this is the subject of a separate application.

What I desire to secure by Letters Patent is:

1) The hereinbefore described method of aerial navigation which consists in raising the machine from its normal starting position in a substantially vertical direction by the propelling means, tilting it into a position suitable for, and supporting it on planes during, lateral flight, tilting it back into its starting position and effecting a landing under the restraining action of said propelling means, as described.

2) The method of transporting a body from one place to another which consists in raising it vertically by a propeller, imparting to it horizontal velocity by the same, supporting it by planes during the flight, taking up its

weight by the propeller and effecting a landing by this means, as described.

3) The above-described method of aerial transportation which consists in raising the body to be transported directly by a propelling device and supporting it in flight by planes driven by the same device.

4) The improved method of aerial transportation of bodies which consists in raising and lowering them directly by the propeller and supporting them in flight by planes driven by the propeller.

5) The method of transporting a body through the air which consists in lifting it by the direct upward thrust of a propeller and supporting it in transit by the reaction of foils, as set forth.

6) The improved method of transport and travel by aeroplane which consists in raising the vehicle directly by a propeller, and supporting it in flight by the planes, as described.

7) The before-described method of aerial transportation which consists in effecting the starting and landing directly by the propeller and the flight by the joint action of this device and planes driven by the same.

8) The improvement in the art of aerial transportation of bodies which consists in supporting them in the air by a propelling device alone in starting and landing, and by planes driven by the device while in flight, as set forth.

9) The improved method of safely effecting the starting and landing of an aeroplane which consists in raising and lowering it by the vertical thrust of a propelling device used to drive the supporting planes in flight.

10) The improved method of transport and travel by aeroplane which consists in placing the vehicle upright and raising it by the direct thrust of the propeller, turning it in the horizontal position and supporting it in the flight by the planes.

In testimony whereof I hereto affix my signature.

Inventor's full name here: }

Nikola Tesla

Oath.

State of New York,
County of New York. } ss.

Nikola Tesla,

the above-named petitioner
being duly sworn, depose s and say s that he is a citizen
of the United States, and resident
of New York, in the County and State of New York,

that he verily believes himself to be the original,
first, and sole inventor of the improvements in
Method of Aerial Transportation,

described and claimed in the annexed
specification; that he do es not know and do es not believe the same
were ever known or used before his invention or discovery thereof, or
patented or described in any printed publication in the United States of
America or in any foreign country before his invention or discovery
thereof, or more than two years prior to this application; or in public use or
on sale in the United States for more than two years prior to this applica-
tion; that said invention has not been patented in any country foreign to the
United States, on an application filed by him or his legal repre-
sentatives or assigns more than twelve months prior to this application, and
that no application for patent on said improvements has been filed
by him or his legal representatives or assigns in any country for-
eign to the United States, except in Gt. Britain, where application
was filed April 1, 1921.

Inventor's full name here: }

Nikola Tesla

Sworn to and subscribed before me this second day of

September, 1921.

15

Violet E. Murchison

(Signature of Justice or Notary.)

(Affix Seal here.)

(Official Character.)

NOTARY PUBLIC, NEW YORK COUNTY
NEW YORK COUNTY CLERK NO. 409,
NEW YORK REGISTERS 152, 3393
EXPIRES MARCH 30, 1923

Fig. 1.

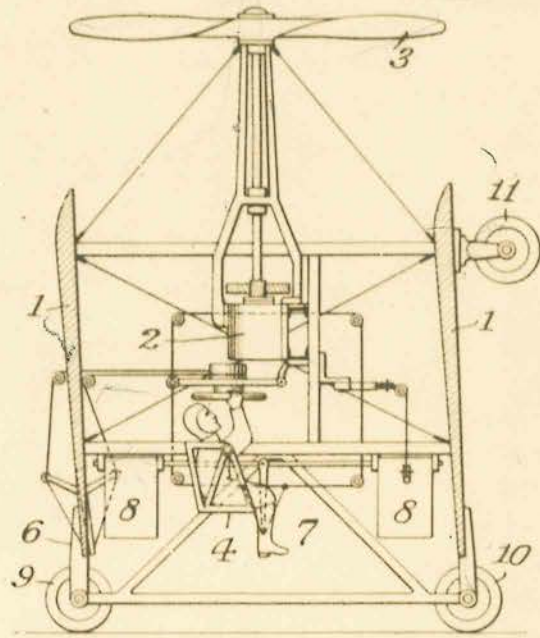


Fig. 2.

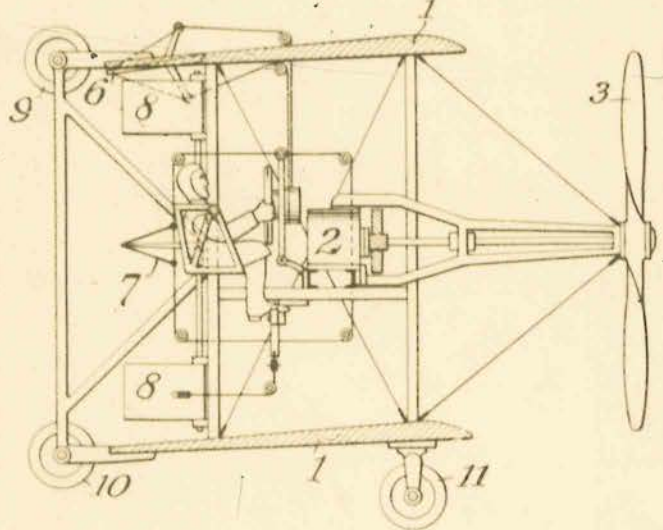
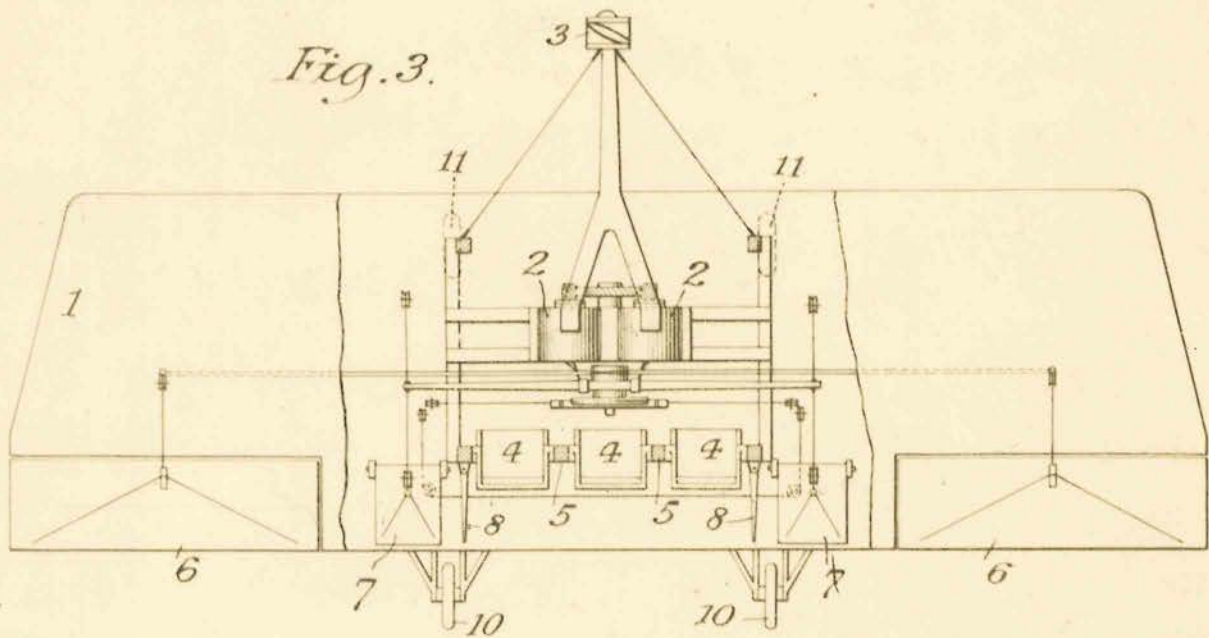


Fig. 3.



Nikola Tesla INVENTOR
BY Rev. Mr. C. H. Hayward ATTORNEY

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name.

All communications respecting this
application should give the serial number,
date of filing, title of invention, and
name of the applicant.

Noe-T

DEPARTMENT OF THE INTERIOR
UNITED STATES PATENT OFFICE

WASHINGTON

Mar. 1, 1922.

Kerr, Page, Cooper & Hayward,515 Liberty St.,New York, N. Y.

Please find below a communication from the EXAMINER in charge of the application of
N. Tesla, Serial No. 499519, filed Sept. 9, 1921, for Method of
Aerial Transportation.

Thomas E. Robertson

Commissioner of Patents.

c 8-2331

Claims 1 to 10 are rejected on any of

ZAHN, 1358603, Nov. 9, 1920, (244-2),
BORKENHAGEN, 1008888, Nov. 14, 1911, (244-2),
GUNDERSON, 1362292, Dec. 14, 1920, (244-2).

The claims are rejected also as improper method claims, the
method described being merely the obvious method of operation of the
devices.

E. J. H.

J. H. McNeill
Examiner, Division 22.

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DIV. XXII PAPER No. 3

APR 12 1922

U.S. PATENT OFFICE

Sub. Pat. Atty.

Div. 22, Room 249.
Appn. of Nikola Tesla,
Serial No. 499,519,
Filed September 9, 1921.
Method of Aerial Transportation.

New York, November 1, 1921.

To the Commissioner of Patents -

The undersigned, attorneys of record in the
above entitled application, hereby appoint PARKER W.
PAGE (Reg. No. 10225), of No. 55 Liberty street, New York,
N.Y., substitute attorney, with full power in the prem-
ises.



Kerr Page Cooper & Hayward

G

Stamp



NIKOLA TESLA
COMPANY

8 West 40th St.
TEL. 9090 BRYANT
NEW YORK

february 28 1923

9421
DIV. XXII. PAPER No.

MAR 2 1923

U. S. PATENT OFFICE

Via. 22 Room 249
In the application of Nikola Tesla
Serial No 499519 filed September 9, 1921 for
"Method of Aerial Transportation"

To the Hon. Commissioner of Patents,

Sir,

Referring to the Official Letter of March 1. 1922

in regard to the above application I beg to amend as follows:

✓ On page 8, 21st line from top, insert period after $\cos \alpha$,
cancel remaining statement on lines 21, 22 and 23 and insert:

"To be explicit, imagine that the aircurrent flowing with the
velocity V along the propeller axis inclined to form an angle α
with the horizontal, be replaced by two streams one vertical and
the other horizontal of velocities respectively equal to $V \sin \alpha$ and
 $V \cos \alpha$, it will be evident that a helicopter in its forward

flight could only approximate and never equal the speed $V \cos \alpha$ of the horizontal aircurrent no matter how much the resistance be reduced for, according to a fundamental law of propulsion, the thrust would be nil at that velocity. The highest efficiency should be obtained with the machine proceeding at the rate $\frac{1}{2} V \cos \alpha$ but the most economical utilization of power would be effected when $\alpha = 45^\circ$ in which case the speeds of both the horizontal and vertical streams will be $0.7 V$. From this it may be inferred that, theoretically, the best performance might be secured in propelling the helicopter forward with a speed more or less approximating $0.35 V$ but the results attained in practice will be necessarily much inferior because without special provisions such as are herein set forth the device, as pointed out above, would plunge down and shoot up in succession, at the same time executing smaller oscillations, which motions will retard its flight and consume a considerable portion of the motive energy all the more so as the losses incident to the controlling means will be correspondingly increased."

On page 10, second line from the bottom, after the period closing preceding sentence insert: "From the foregoing it will be understood that, simultaneously with the tilting of the machine, the operator will increase the thrust of the propeller in order to compensate for the reduction of sustaining force which follows inevitably from the diminution of angle α and before

the reaction of the planes can come into full effect. He will ^{thus} ~~then~~ prevent a downward plunge and the production of dangerous oscillations which have been dwelt upon above, and by suitable manipulation of the apparatus and gradual cutting down of the power developed by the prime mover, as forward velocity is gained and the planes take up the load, he may cause the machine to advance horizontally along a sensibly straight line, a condition essential to the attainment of the best practical results."

✓ On page 11, second line from top, after the period closing ~~the~~ preceding sentence, insert: " Obviously, as the device is slowed down and righted causing the planes to lose part ³ or all of their sustaining effort, the operator will apply ⁴ more power to the propeller increasing thereby the thrust ^{Q3} to the required magnitude and in all such operations of starting and landing as well as tilting for regulating the height, meeting the air conditions or for other purposes it will be his object to modify the propeller thrust in about the same measure as the varying reaction of the planes may demand in order that the lifting force be sensibly constant. Evidently also, whenever necessary or desirable, power far in excess of that normally required may be applied during the flight and the machine propelled at a greatly increased speed."

✓ On same page, ninth line from bottom, cancel words

"a helicopter plane" and substitute therefor "an aeroplane".

✓ On page 12, fourth line from top, replace the period after the word propeller by a comma and add "or other means known in the art."

✓ On same page, after the eleventh line from top, insert paragraphs:

Q⁴ To sum up, the helicopter type of flying machine, especially with large inclination ^{angle} of the propeller axis to the horizontal, at which it is generally expected to operate, is quite unsuitable for speedy aerial transport; it is incapable of proceeding horizontally along a straight line under the prevailing air conditions; it is subject to dangerous plunges and oscillations and, what is most important from the commercial and practical point of view, it is almost certainly doomed to destruction in case the motive power gives out. These drawbacks and defects are overcome by the methods and apparatus I have described through which a novel type of flying machine may be realized possessing all the advantages of the helicopter being at the same time safe and capable of a speed equal to or even greatly exceeding that of the present aeroplane."

Q To my knowledge various forms of aeroplanes have been proposed with the object of attaining similar

results but a careful study shows that none of them is capable of the actions as those here contemplated for want of proper methods of operation as well as suitable apparatus."

✓ Cancel all claims on pages 12, 13 and 14 and substitute the following:

Q5 1. The hereinbefore described method of aeroplane transportation which consists in developing by the propelling device a thrust greatly in excess of the normal, causing thereby the machine to rise in a direction approximately vertical, tilting it in the air simultaneously increasing the thrust then gradually reducing it as forward speed is gained and the planes take up the load, thus maintaining the lifting force sensibly constant during the flight, slowing down the machine and tilting it back to about the original position at the same time increasing the thrust and effecting a landing under the restraining action of the propelling device.

Sub B1 2. The method of operating a helicopter which consists in varying the thrust of the propeller simultaneously with the changes of inclination of its axis thus maintaining the lifting force sensibly constant during the forward flight, as set forth.

3. The above described method of transporting

a body from one place to another by aeroplane which consists in applying excessive power to the propeller in vertical position, developing thereby a lifting force sufficient to cause the machine to rise, tilting it applying first more power to increase the thrust then gradually diminishing the power and transferring the load from the propeller to the planes, reducing the horizontal velocity, tilting back the machine and controlling the power so as to effect a slow descent upon the landing place under the restraining action of the propeller.

4. The method of aerial navigation which consists in controlling the power supplied to an aeroplane propelling device and the position of the machine so as to cause it to rise from its starting place in a direction approximately vertical, proceed horizontally at a sensibly uniform elevation from the ground and to descend slowly to its landing place in a direction nearly vertical, as set forth.

5. The method of transportation by aeroplane which consists in controlling the speed of the propeller and inclination of its axis so as to cause the machine to rise in a direction approximately vertical, proceed

horizontally at the desired speed and descend safely to its landing place in a direction nearly vertical, as described.

6. In the transport of bodies by aeroplane the method of varying the propeller thrust and reaction of the planes so as to maintain the lifting force sensibly constant during the forward flight, as set forth.

7. In the transport of bodies by ^{an} aeroplane adapted for vertical rise and descent the method of preventing dangerous plunges and oscillations which consists in varying the propeller thrust and reaction of the planes so as to maintain the lifting effort sensibly constant, as described.

8. In the operation of an aeroplane adapted for vertical rise and descent the method of controlling the power so as to cause the machine to be lifted in a nearly vertical direction by the propelling device alone and to land supported only by the reaction of the planes, as set forth.

I am suffering from a prolonged attack of grip and am compelled to address this communication without the guiding advice of my counsel but hope that any oversight or error due to my limited knowledge of legal facts and formalities will not be interpreted to my disadvantage.

Respectfully submitted

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name.

All communications respecting this
application should give the serial number
date of filing, title of invention, and
name of the applicant.

DEPARTMENT OF THE INTERIOR
UNITED STATES PATENT OFFICE

Car-CT

WASHINGTON

October 12, 1923

Kerr, Page, Cooper & Howard55 Liberty St.New York, N. Y.

Please find below a communication from the EXAMINER in charge of the application of

Nikola Tesla, Ser. No. 499,519, filed Sept. 9, 1921, forMethod of Aerial Transportation.

Thomas E. Robertson

Commissioner of Patents.

e-2881

In response to amendment filed March 1, 1923.

Claims 1 to 8 inclusive are rejected as failing to
distinguish patentably over:

Zahn 1,358,603 or over Gunderson 1,362,292 both of
record.

The practical operation of these two devices would
necessitate the steps set up in applicant's claims.

BAC

J. M. Colwell
Examiner, Division 22.



#6
B
DIV. XXII PAPER No.

OCT. 9 - 1924

U.S. PATENT OFFICE

Div. 22, Room 249.

Appn. of Nikola Tesla,
Serial No. 499,519,
Filed September 9, 1921.

9428

Method of Aerial Transportation.

New York, October 7, 1924.

Hon. Commissioner of Patents,

Washington, D.C.

Sir -

In response to the Office action of October 12, 1923, in the above named application, the following amendment is presented for consideration.

Cancel the claims now on file and substitute therefor the following --

B1
1. The hereinbefore described method of aeroplane transportation which consists in developing by the propelling device a vertical thrust in excess of the normal, causing thereby the machine to rise in an approximately vertical direction, tilting it and simultaneously increasing the power of the motor and thereby the propeller thrust, then gradually reducing the power and thrust as forward speed is gained and the planes take up the load, thus maintaining the lifting force sensibly constant during flight, tilting the machine back to its original position and at the same time increasing the power of the motor and thrust of the propeller and effecting a landing under the restraining action of the same.

2. The method of operating a helicopter which consists in varying the power of the motor and thereby the thrust of the propeller according to the changes of inclination of its axis, so as to maintain the lifting force sensibly constant during the forward flight.

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3. ~~The method of operating a heavier than air flying machine which consists in varying the speed of the motor and thereby the thrust of the propeller concurrently with the changes of inclination of the axis of the device.~~

3. ~~1.~~ The above described method of transporting from place to place a heavier than air flying machine, which consists in applying power to the propeller while its axis is in a vertical position sufficient to cause the machine to rise, tilting it and at the same time applying more power to increase the thrust, then gradually diminishing the power as the load is transferred from the propeller to the planes, tilting back the machine and so controlling the applied power as to effect a slow descent upon the landing place under the restraining action of the propeller.

4. ~~3.~~ In the transport of bodies by aeroplane, the method of controlling the propeller thrust and reaction of the planes by varying the power of the motor correspondingly with the inclination of the machine so as to maintain the lifting force sensibly constant during the forward flight.

REMARKS.

Up to the present time the inventor has prepared and prosecuted this application entirely unaided. His efforts have suffered from the handicap of unfamiliarity with the required forms of claims and the case has been brought to me for attention. Mr. Tesla's powers of descrip-

tion and statements of operation are unequalled, and upon careful consideration of the application nothing has been found that is open to criticism in this regard. The claims, however, have been amended and are now believed to properly define the real invention.

The Examiner in his letter of October 12, 1923, expresses the view that the practical operation of either of the devices shown in the patents cited necessitates the steps involved in applicant's claims as then construed. The attention of the Examiner is now called to the manifest fact that neither of these patents shows means capable of performing applicant's method and neither contains the slightest suggestion of any means capable of practicing the same successfully. It would even seem that if by chance some such means had been provided, this in itself would not detract from the novelty and originality of the invention which Mr. Tesla has made.

Almost all important discoveries appear obvious in the light of subsequently acquired knowledge, to such a degree that the question is often asked "why nobody thought of it before". One of the most revolutionary inventions of recent time, the polyphase motor, and more especially the induction motor, falls directly in this category, and great care should be exercised in judging of the merits of such inventions, after the fact.

Applicant's invention is far from being self-evident. On the contrary it came only after prolonged study, and Mr. Tesla's long continued and painstaking efforts to produce a flying machine free from the shortcomings of existing types, and satisfying all practical requirements.

That he has made a notable advance may be readily seen by a careful examination of the prior state of the art and the technical literature relating thereto in which the cardinal points brought out by him are completely ignored. The two references afford strikingly illustrative examples of this.

In the patent to Gundersen it is stated (page 2 lines 12 to 15); "When the desired altitude has been attained, the operator through his controls puts the machine on an even keel and continues his flight as usual." This erroneous impression that such a change of position could be brought about readily and without risk has been heretofore general and has been further strengthened by the observation that an experienced ^{aeroplane} operator can easily perform evolutions in which the propeller axis and planes assume all positions and are sometimes vertical. But it is entirely overlooked that such evolutions are made possible only by skillful utilization of momentum, which is negligible in the present case under consideration.

It is shown, for example, by applicant that the tilting must inevitably result in a downward plunge, all the more serious as for obvious reasons the controlling means are slow in becoming effective. In a few seconds the machine will fall through a great distance and gain a speed sufficient to damage or destroy it.

As reflecting the state of the art prior to applicant's disclosures, the passage from the Zahn patent (page 2 lines 56 to 60) may be cited: "As above pointed out the weight of the motor units per h.p. should be minimized and reduced to at least 2 lbs., otherwise operation of the craft as a helicopter would be impossible." The

patentee is a very able expert and merely expresses the prevailing faulty opinion. Applicant has shown that the vertical thrust can be increased virtually at will, and motors of any weight, within reasonable limits, successfully employed. But contrary to general expectations, the speed of this type must always be lower than that of the aeroplane no matter how much its body resistance and weight of the machinery is reduced.

Flying machines intended to operate both as helicopters and aeroplanes have been proposed long ago and various forms devised during the past thirteen years, but no useful results have been thus far achieved with any of them for want of a proper method of operation and suitable means of propulsion. Applicant's invention supplies those requisites and removes the inherent limitations of both types. His improvements are unquestionably novel and original and he is justly entitled to the claims now submitted for consideration.

Reconsideration is respectfully requested.

Respectfully submitted,

Parkman. Rose
atly.

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

All communications respecting this
application should give the serial number,
date of filing, title of invention, and
name of the applicant

DEPARTMENT OF THE INTERIOR

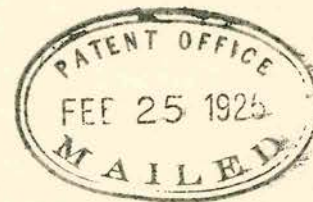
Mor-MK

UNITED STATES PATENT OFFICE

WASHINGTON

February 25, 1925.

Parker W. Page,
55 Liberty St.,
New York, N. Y.



Please find below a communication from the EXAMINER in charge of the application of
Nikola Tesla, Ser. No. 499,519, filed Sept. 9, 1921, for
Method of Aerial Transportation.

6-2631 G P O

Thomas E. Robertson

Commissioner of Patents.

In response to amendment filed Oct. 8, 1924.

Claims 1 to 5 are rejected on any one of Gunderson
1,362,292 (244-2) or Zahm 1,358,603 (244-2), both of record.

Both references show the method of starting off with
the propellers in a horizontal plane and describe how the
airplane is tilted to a horizontal plane by means of the
controlling means. The variation in the power supply is
obvious as it is a well known fact that less power is
necessary when the supporting surfaces are in action than
when they are not.

This rejection is final.

J. H. Colwell
Examiner, Division 22.

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499,519-8

U. S. PATENT OFFICE

FEB 26 1926

ON RECEIPT FILED

Div. 22, Room 106.

Application of Nikola Tesla,
Serial No. 499,519,
Filed September 9, 1921.

Method of Aerial Transportation.

New York, February 18, 1926.

Hon. Commissioner of Patents,
Washington, D.C.

Sir -

Mr. Parker W. Page, my attorney of record in the above entitled application, having retired from practice, all powers of attorney heretofore given in respect to said application are revoked, and I hereby appoint COOPER, KERR & DUNHAM (a firm composed of Drury W. Cooper, John C. Kerr, and Sturges S. Dunham, Reg. No. 11648), of No. 42 Broadway, New York, N.Y., my attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent Office connected therewith.



Nikola Tesla

FEB 26 1926

U. S. PATENT OFFICE

13,354

22

EHP



Div. 22, Room 106.

Application of Nikola Tesla,
Serial No. 499,519,
Filed September 9, 1921.

Method of Aerial Transportation.

Hon. Commissioner of Patents,
Washington, D.C.

Sir -

I hereby appeal to the Examiners-in-Chief,
from the decision of the Primary Examiner, in the matter
of my application above identified, which on February
25, 1925, was rejected the second time.

The grounds on which appeal is taken are as
follows:

The Examiner erred in rejecting my said appli-
cation on the references of record.

An oral hearing is requested.

Signed at New York, N.Y., this 18th day of Feb-
ruary, 1926.

Nikola Tesla

By Cooper, Kim & Dunham
his attys.

34

DRURY W. COOPER
JOHN C. KERR
STURGES S. DUNHAM

THOMAS J. BYRNE
FELIX THOMAS
H. FRANK WIEGAND
THOMAS H. BROWN
ERNEST D. GIVEN
ALLAN C. BAKWELL
GEORGE F. DES MARAIS

LAW OFFICES OF

COOPER, KERR & DUNHAM

42 BROADWAY, NEW YORK

CABLE ADDRESS: "KERCURTIS"

February 18, 1926.

Hon. Commissioner of Patents,
Washington, D.C.

Sir -

We send herewith check to your order for \$20. in payment of fees for the accompanying appeals to the Examiners-in-Chief in the applications of Nikola Tesla, Serial Nos. 499,518 and 499,519. Please note that to each appeal is annexed a power of attorney.

Yours respectfully,

Enclosures.

Cooper, Kerr & Dunham

DEPARTMENT OF COMMERCE,
United States Patent Office,
Washington, D. C.

MAILED
MAR 2- 1926

In re application)
Niholas Tesla,)
Serial No. 499,519,)
Filed Sept. 9, 1921, for)
Method of Aerial Transportation.)

BEFORE THE
EXAMINERS-IN-CHIEF ON
APPEAL.

EXAMINER'S STATEMENT.

This is an appeal from the final rejection of
claims 1, 2, 3, 4 and 5 which are:

1. The hereinbefore described method of aeroplane transportation which consists in developing by the propelling device a vertical thrust in excess of the normal, causing thereby the machine to rise in an approximately vertical direction, tilting it and simultaneously increasing the power of the motor and thereby the propeller thrust, then gradually reducing the power and thrust as forward speed is gained and the planes take up the load, thus maintaining the lifting force sensibly constant during flight, tilting the machine back to its original position and at the same time increasing the power of the motor and thrust of the propeller and effecting a landing under the restraining action of the same.
2. The method of operating a helicopter which consists in varying the power of the motor and thereby the thrust of the propeller according to the changes of inclination of its axis, so as to maintain the lifting force sensibly constant during the forward flight.
3. The method of operating a heavier than air flying machine which consists in varying the speed of the motor and thereby the thrust of the propeller concurrently with the changes of inclination of the axis of the device.
4. The above described method of transporting from place to place a heavier than air flying machine, which consists in applying power to the propeller while its axis is in a vertical position sufficient to cause the machine to rise, tilting it and at the same time applying more power to increase the thrust, then gradually diminishing the power as the load is transferred from the propeller to the planes, tilting back the machine and so controlling the applied power as to effect a slow descent upon the landing place under the restraining action of the propeller.

5. In the transport of bodies by aeroplane, the method of controlling the propeller thrust and reaction of the planes by varying the power of the motor correspondly with the inclination of the machine so as to maintain the lifting force sensibly constant during the forward flight.

The references cited are:

Gunderson	1,362,292	Dec. 14, 1920,	(244-2) and
Zahm	1,358,603	Nov. 9, 1920,	"

Claims 1 and 4 are similar and describe the steps of the applicant's method of rising vertically, then tilting the machine by means of the control surfaces for horizontal flight and again tilting the machine back to the vertical position for landing. The propeller power is varied as necessary.

Claims 2, 3 and 5 claim broadly a method of propulsion in which the power of the propeller is varied with the inclination of its axis.

Claims 1 and 4 are rejected on either Gunderson or Zahm. Gunderson on page 2, lines 1-31 describes the rising, forward and landing operations clearly. Zahm on page 3, lines 1-35 describes the method of rocking the machine backward until it points vertically where it rises and then straightens out. In both Gunderson and Zahm, the examiner holds the necessary power to maintain the desired flight will be used. Therefore, since it is well known in the art that less power is necessary when the supporting surfaces are in action than when they are not, it is held that nothing novel and patentable resides in the variations in the propelling power as claimed.

Claims 2, 3 and 5 are rejected on either Gunderson or Zahm, as above. Moreover, these claims are a simple expression of what every aeroplane in flight does. When a certain lifting force is desired, the more supplied by the supporting surfaces, the less is required of the propeller.

jam

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J. H. C. Hull
Examiner, Division 22.

ADDRESS ONLY
THE COMMISSIONER OF PATENTS
WASHINGTON, D. C.

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE
WASHINGTON

March 12 , 1926.

Sir:

The case of Nikola Tesla

Serial
~~Interference~~ No. 499,519 will be heard by the EXAMINERS IN CHIEF
on the 7th day of July , 1926.

The hearings will commence at ONE O'CLOCK and as soon as
the argument in one case is concluded the succeeding case will
be taken up.

If any party, or his attorney, shall not appear when the
case is called, his right to an oral hearing will be regarded
as waived.

The time allowed for arguments is as follows:

Ex parte cases, thirty minutes;
Inter partes appeals final hearing, one hour each side.

By special leave, obtained before the argument is commenced,
the time may be extended.

The appellant shall have the right to open and conclude in
inter partes cases, and in such case a full and fair opening
must be made.

Briefs in inter partes appeals must be filed in accordance
with the provisions of Rules 144 and 163.

Respectfully,

Thomas E. Robertson
Commissioner of Patents.

To

To Messrs. Cooper, Kerr & Dunham, Attys.,
45 Broadway,
New York, N. Y.

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Appeal No. 13354 Paper No. 12
Brief.

IN THE UNITED STATES PATENT OFFICE

Before the Board of Honorable Examiners-in-Chief

In the matter of the applications
for Letters Patent in the name of

NIKOLA TESLA

Ser. No. 499,518 - Apparatus for Aerial Transportation

Ser. No. 499,519 - Method of Aerial Transportation

Brief for Applicant

To the Hon. Board of Examiners-in-Chief:

First let it be understood that the apparatus of these inventions is not an aeroplane of the usual type.

The inventions involved in the appealed claims of the above entitled applications have to do with a method and an apparatus in that class of aerial vehicles commonly known as helicopters or combined helicopters and aeroplanes.

The general course of flight of such machines is characterized by vertical or substantially vertical ascent to and descent from attitudes of substantially horizontal flight.

The apparatus heretofore proposed is commonly characterized by the utilization of one and the same system of thrust generating apparatus for substantially vertical ascent to and descent from horizontal flight.

The direction of the thrust is generally parallel or substantially parallel to the principal axis of the machine.

The apparatus of the applicant is of the combined helicopter and aeroplane type as distinguished from the simple helicopter type. In the simple helicopter type both the sustaining and the propelling forces are derived in all

attitudes of flight from a rotating propeller or propellers constituting the thrust generating apparatus. In the combined helicopter and aeroplane type the force of sustentation is during the vertical or substantial vertical ascent derived from the propeller or propellers which constitute the thrust generating apparatus, but during the horizontal or substantially horizontal flight is derived from aeroplanes which are propelled substantially horizontally by the thrust generating system.

But during the attitudes of ascent and descent the combined helicopter and aeroplane behaves substantially as a simple helicopter.

So far as applicant is aware there has been achieved no truly successful flight or flights with either of these types of machines. The only heavier than air machine, which it would seem from the reports, has been successful in substantially vertical ascent to and descent from the position of horizontal flight, is what is known as the "autogyro", a machine in which two thrust generating systems are used, one system in the manner of a simple helicopter serving for sustentation throughout flight of the machine, and an entirely independent system at right angles thereto, generating thrust to draw the machine along a horizontal path. This machine is recently reported to have made numerous ascents and descents without serious accident. Diagrammatically, it is illustrated in Fig. 1 of the appendix hereto. The utilization of the independent thrust generating systems for vertical and horizontal flight, respectively, render unnecessary substantial change in the attitude of the apparatus for transposition of flight from the vertical to the horizontal and vice versa.

But machines of the type of applicant's invention pertaining more particularly to those which utilize but a single thrust generating system relatively fixed as respects the principal axis of the machine are dependent for transportation from vertical to horizontal flight and vice versa upon substantial change in the attitude of the machine itself and of the thrust generating system.

As shown in the drawings of the applicant, one and the same propeller is utilized to draw the machine substantially vertically and ^{also} for transposition to horizontal flight. The entire body of the machine including the axis of the thrust generating system is in the transposition turned through substantially 90°.

No such machine, we repeat, so far as is known to applicant, has achieved success.

All of them, prior to applicant's invention, have been subject to numerous shortcomings (not necessary to mention here, but see specifications) and to one great failing. Whenever in the course of flight, particularly substantially vertical flight, the principal axis of the machine is inclined, albeit slightly to the vertical, with a view to transposing the flight from the vertical to the horizontal, these machines have lost elevation and gotten beyond control and have been wrecked. This has always been the case when the inclination of the principal axis to the vertical became considerable. The same has been true also of transposition from horizontal to vertical.

Applicant has sought for and has found the reason of these failures. He has devised an entirely new method of operation of such machine, the use of which eliminates these failures. He has invented also an entirely new apparatus. By the use of applicant's method and apparatus success is assured.

The failures he found due to the heretofore unappreciated fact that when during the substantially vertical ascent

(4)

(5)

anywhere near the earth it cannot but be wrecked. This is or descent a change of attitude of the principal axis of the machine and thrust generating system is brought about, instantaneous, abrupt and material reduction of the sustaining force results. This unavoidably entails an alternate fall and rise of the machine through considerable distances, and irrespective of the danger caused thereby the oscillations persist for so long a period that a practical use of such a machine is absolutely out of the question. Referring to Fig. 2 of the appendix, W is the force of gravity acting on the machine. A lifting force L equal to W is necessarily derived from the thrust generating system before the machine can be started, not to mention sustained in the air. To accomplish any vertical ascents or descents the force L must be somewhat greater than the force W. Assuming the principal axis to be turned through 30° as indicated, the sustaining force is cut down by the amount L, and the machine must fall through a great distance under the action of the force of gravity and the momentum acquired. When the thrust generating system is inclined 60° the sustaining force L is reduced to one half the necessary value for sustentation. The figures given by the applicant in his specification, page 6, of his method application, goes to show a calculated drop of 3840' resulting from such a material inclination. And the actual drop will be far greater because the kinetic energy accumulated by the machine in the course of this tremendous drop has not been taken account of in this calculation. The attitude of a machine needs to be changed not merely through 60° but through nearly 90° before high speed horizontal flight can be attained. A still greater drop will inevitably follow. If the machine is

anywhere near the earth it cannot but be wrecked. This is what has happened sooner or later in the case of all machines known to the applicant.

If, however, great height might be reached (this, by the way, has never been done), such a machine might continue flight along a path such as illustrated in Figure 3 of the appendix, a curved progressively decreasing amplitude but no such machine could ever be made a practical success. It is absolutely essential that the proper method of control and suitable apparatus be devised in machines of this type just as has been found indispensable in the case of machines of the aeroplane type.

It was lack of control which resulted in the failure of one and all of the early aeroplanes. The Wright Brothers found the way to control the aeroplane. The applicant has found the way to control the helicopter and the combined helicopter and aeroplane.

By reference to Fig. 4. of the appendix applicant's method may be stated in simple terms. He increases the thrust T derived from the generating system as the axis of the same is inclined sufficiently to compensate or more than compensate for the attendant reduction of the sustaining force L . On vertical ascent the thrust T will have a value substantially equal to the required lifting force L or sufficiently greater than L to attain the desired speed of vertical ascent. When, however, the attitude of the machine is changed 30° the axial thrust T will have a much greater value $T-1$ such as to give substantially the same lifting force L as before. And, at say 60° , it will have a still greater value $T-2$, but such as to yield the same lifting force L so that the machine will proceed horizontally. And so on.

So the lifting forces L , no matter to what degree it exceeds the force W necessary for mere sustentation, may be made "sensibly constant" during the changes of inclination of the machine. The thrust is increased "concurrently" and "correspondingly" to change of inclination of the machine as brought about by the operation of its rudders.

When this method is carried out not only is all danger whatsoever of an abrupt fall eliminated, but perfect control of the machine at all times is assured. For not only is the force L maintained undiminished irrespective of the change of the angle of inclination, but also the force L is maintained sufficiently greater than the force W to insure the speed to make perfect the response of the machine to its controls.

Now this concept was not invented by Gunderson or Zahm. Nor is it the contention of the Primary Examiner that either of these prior inventors did have this concept. The drawings contain no reflection of it. The specifications contain no hint of it. The Primary Examiner but surmises "the propeller's own power is varied as necessary". And again the Examiner holds "the necessary power to maintain flight will be used". And regarding the claims "these claims are a simple expression of what every aeroplane in flight does." Let us see.

The Examiner himself exposes the fallacy of these surmises. He says first - "It is well known in the art that less power is necessary when the supporting surfaces are in action than when are not". Exactly the contrary is true during the period of transposition from vertical to horizontal flight, as comparison of Figs. 2 and 4 clearly shows. Much more power is necessary during the steps of transposition before the horizontal is approached. And again the Examiner says - "When a certain lifting force is desired, the more supplied by the supporting

(7)

surfaces, the less is required of the propeller". This is only true as an abstract statement, but the conditions in an ordinary aeroplane and the type described by applicant are essentially different. In the former owing to the large area of the surfaces the planes take up the propeller thrust very quickly even at low speed, while in the type described by applicant the planes are practically of no effect in the early stages of the flight.

During all those earlier stages much more lifting force is required of the propeller than of the planes.

Scientific men and experts have fallen into the same and other errors which have been pointed out by applicant. They have not perceived the situation before or during the transposition to and from horizontal flight. They have seen only the situation during normal aeroplane flight, and have erroneously tried to apply it to the situations during the stages of transposition.

Gunderson goes so far in error (page 2, lines 15 to 25) as to prescribe retardation (!!) of the propellers to effect a landing by vertical descent, "to settle tail first". Only a crash can result. Nor can anything else result when the operator, in attempting ascent (page 2, lines 12 to 15) "puts the machine on an even keel" "through his controls" and without the concurrent and corresponding great increase in thrust prescribed by Mr. Tesla.

Zahm in his turn but prescribes "sufficient vertical lift" "to lift the machine bodily in a vertical line" (page 1, lines 55 et seq.) "or at a slight inclination" (page 2, line 29). But of the magnitude and source of the great power required for the transpositions, nothing is said, not to mention its "concurrent" and "corresponding" increase with increase in inclination now for the first time shown to be the true method of operating this type of machine.

Nor do Gunderson and Zahm or either of them show or describe any apparatus by which this applicant's method can be carried out. The ordinary internal combustion engines of the reciprocating type which they use are wholly incapable of developing thrusts of the great magnitude required. It is a well known fact that the airplane motor of today is operated continuously at its very maximum capacity, even under normal horizontal flight. Requirements for vertical ascent are much greater as Figure 4 hereof should constantly remind us. Zahm proposed using the lightest motor then available (2 lbs. per H. P.) (page 1, line 38) and choosing a propeller of lowered pitch (page 1, line 64 and page 2, line 25) before he could derive more than "sufficient vertical lift" "to bodily lift the machine on a vertical line".

The ~~internal~~ combustion engine of the reciprocating type has no overload capacity whatever - superpower can only be had by supersized motors. Such motors through their superweight directly annul the attendant increase in thrust. Moreover, motors of such size materially cut down the useful load the machine can carry. And they are not only imperfectly responsive, but very tardily responsive to accellerity control. Zahm and Gunderson, like many others, but saw the problem. They did not provide either the method or the apparatus which solve it. These remained for this applicant.

Applicant's apparatus embodies in the combination a motor of a different kind, a motor of special adaptation. It is a prior art motor, one of the dozens that the public, including applicant, have had before them a number of years. Yet none, save applicant, has made the right combination.

Broadly speaking, it is a motor operating on a wide variation of both pressure and volume, a motor capable of instantaneous acceleration and deceleration, of perfect and perfectly graduated response, a motor with a manifold capacity for overload. More specifically, a motor "having a rotor of plane spaced disks with central openings, and inlet and outlet orifices at the periphery and center respectively". Such a motor (it just so happens itself invented by applicant in 1913) applicant utilizes in this new and patentable combination. Such a motor applicant specifically adapts to the combination by regulating its size to its normal load requirements, its capacity for overload, the means to impose overload upon it to the manifold greater requirements of the transposition from vertical to horizontal flight, a form of manifold greater than that required in normal flight. This apparatus, and this only, can produce under 47

adequately flexible and instantaneous control, the great thrusts temporarily required for the transposition stages of the flight of the long time proposed helicopter, of the helicopter-aeroplane, of the heavier than air machine drawn in both vertical and horizontal flight by the single system of thrust generating apparatus.

And with it a great new art is born - a new and great class of machines rendered available to mankind - a class of machines eliminating without complications the heavy vexing problems of launching and landing heavier than air machines in small compass - useful alike on land and sea - in war and in peace. Cumbersome launching and landing apparatus of enormous price is no longer needful, - extended tracts of land for field facilities and housing are not necessary. The machine itself has been made safe.

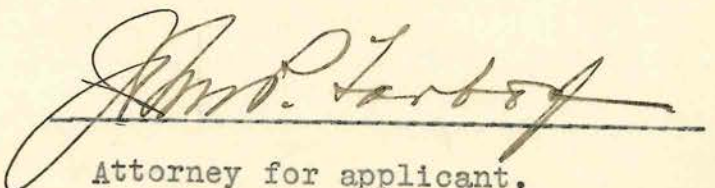
These inventions are of the basic kind most benefiting mankind - the kind the law unfailingly protects. In the case of the automobile, half dozen of the countries most eminent lawyers, and the lower and upper branches of one of the strongest courts in the land (The Second Circuit) held the combination of the liquid hydrocarbon motor of the compression type with the vehicle elements *per se* a patentable combination. (Electric Vehicle Co. v. Duerr, 172 F. 923) (Columbia Motor Car Co. v. Duerr, 184 F. 893). Here the vehicle elements per se were all old. It had previously been proposed to put other types of liquid hydrocarbon engines in such vehicles. Yet counsel and courts agreed that the use of the particular motor which made the vehicle a true success rendered the combination patentable. The lower court held the claims

sufficiently broad in scope to cover both the constant pressure and constant volume (Otto) engines. And while the upper court held that the prior art required such restricted interpretation of the claims that they could not include the constant volume engine of the present day, the claims were nevertheless held valid over the prior art to the extent of covering the constant pressure engine (Brayton), and the fact that they did not include the Otto engine in their scope was specifically assigned to error in the choice of engine made by the inventor. "In the light of courts, we can see that had he appreciated the superiority of the Otto engine and adapted that type for his combination, his patent would cover the modern automobile", said the Court.

Mr. Tesla, on the other hand, has qualified in full for the protection of his invention in precisely this manner. He has chosen and adapted a motor of peculiar characteristics to the helicopter and helicopter-aeroplane. When, eight years after he invented the radically new type of prime motor he uses, he took up the study of the helicopter and helicopter-aeroplane, many different types of motor were available. His choice and adaptation of this one achieved for the world this pioneer invention in an heretofore unproductive field.

He has effected the right combination. - He has sought protection promptly. He asks the allowance of claims of the scope to which pioneer inventions are always entitled.

49



Attorney for applicant.

FIG. 1.

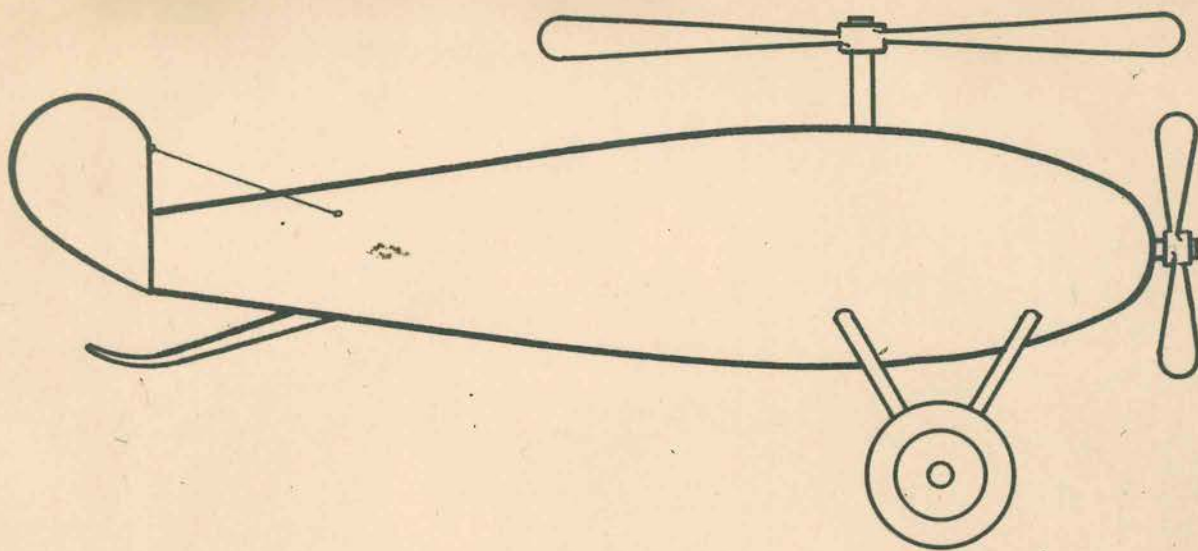


FIG. 3.

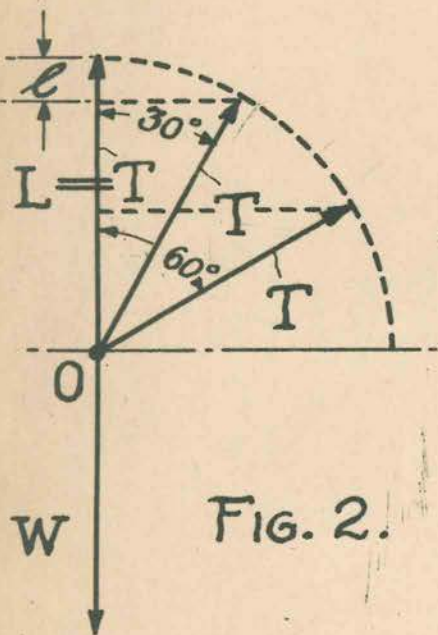
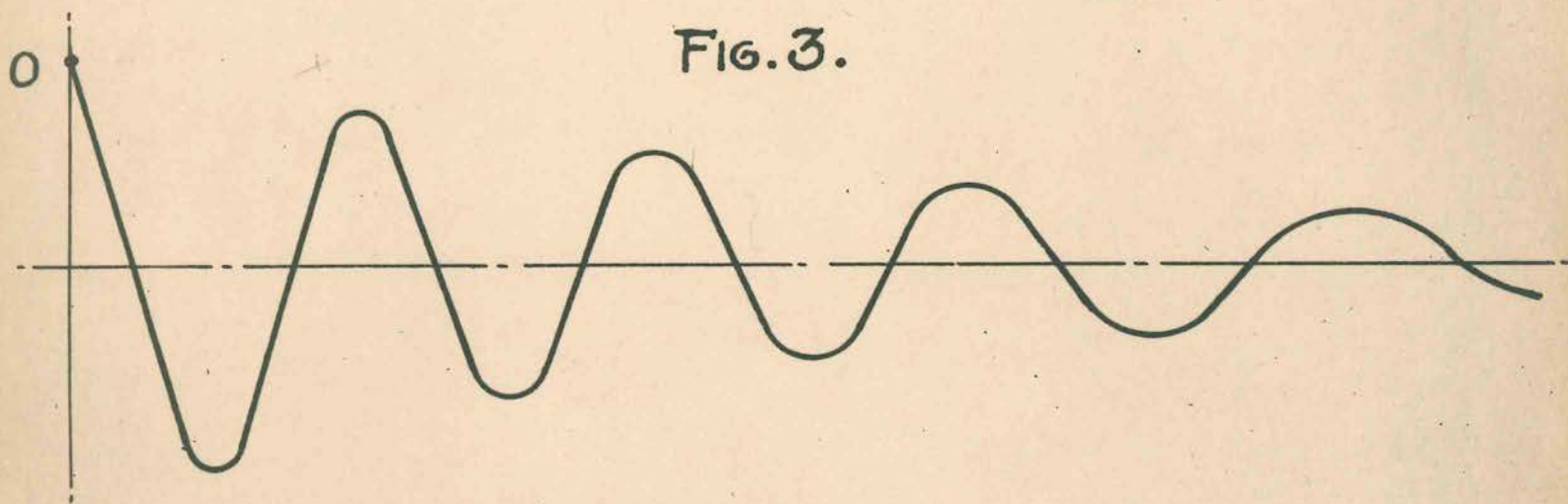


FIG. 2.

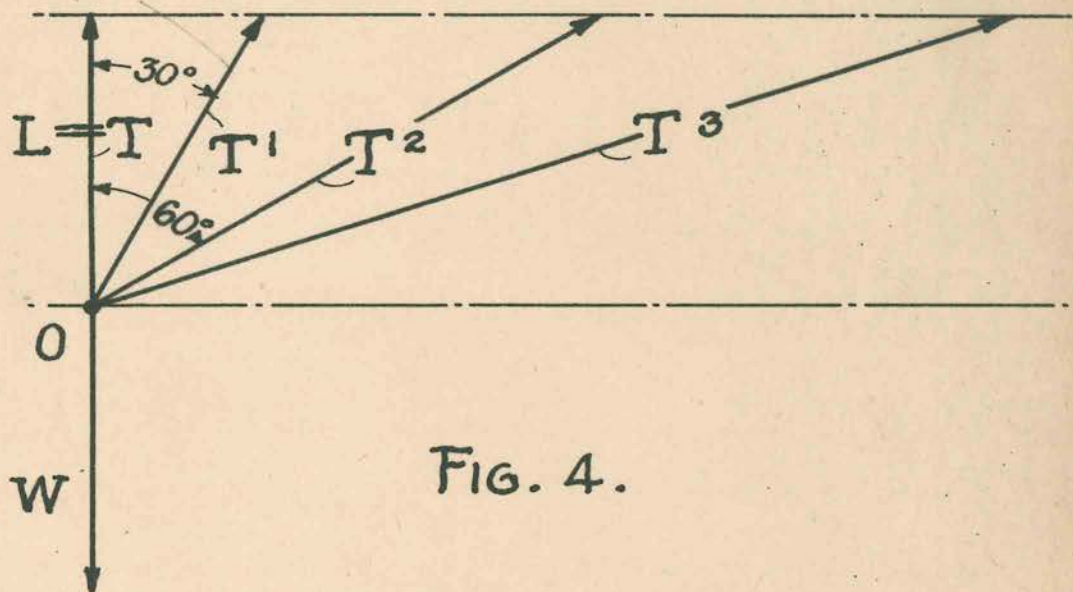
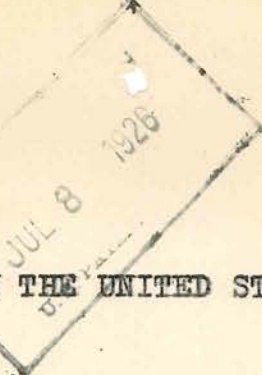


FIG. 4.



IN THE UNITED STATES PATENT OFFICE



#13

In re Application of
N. TESLA
METHOD of AERIAL TRANSPORTATION
Serial No. 499,519

Div. 22
Room 249

REVOCACTION OF POWER OF ATTORNEY

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

I hereby revoke the power of attorney heretofore given by me in the above entitled application to Messrs. Kerr, Page, Cooper & Hayward and appoint in their stead JOHN P. TARBOX, #9023, whose address is 5026 Erringer Place, Philadelphia, Pennsylvania, with full powers of substitution and revocation, to prosecute this application before the Patent Office, to conduct all other proceedings with respect thereto, and to receive the patent.

Respectfully submitted,

Nikola Tesla
Applicant

Accepted

JUL 8 1926
J. E. Robertson
Commissioner

51

EEG

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE

WASHINGTON

July 9, 1926.

John P. Tarbox,
5026 Erringer Place,
Philadelphia, Pa.

Applicant Nikola Tesla
Serial No. 499,519
Filed Sept. 9, 1921
For Method of Aerial Transportation.

In this case your power of attorney has been accepted.

Respectfully,

Thomas E. Robertson

Commissioner.

11-8898

Revoking power of attorney
to

Cooper, Kerr & Dunham,
42 Broadway,
New York, N. Y.

52

IN THE UNITED STATES PATENT OFFICE

In the matter of the applications
for Letters Patent in the name of

NIKOLA TESLA

Ser. No. 499,518 - Apparatus for Aerial Transportation

Ser. No. 499,519 - Method of Aerial Transportation



Before the Honorable Board
of Examiners-in-Chief

A F F I D A V I T

STATE OF PENNSYLVANIA }
COUNTY OF PHILADELPHIA } SS.

Nikola Tesla, being duly sworn, deposes and says
that he is the above entitled applicant, and further says
as follows:

Both patents quoted by the Examiner deal with the
ordinary aeroplane, the specifications being quite explicit
in this respect. No new type of heavier-than-air flying
machine is contemplated or even a suggestion made how the
devices described, if at all operative, might be employed in
a machine other than the usual aeroplane. It is also evident
from the specifications that the patentees rely entirely
on reciprocating engines such as are in common use and the
descriptions of their apparatus do not contain the slightest
hint of a motor of different construction and characteristics.

53
The patent granted to Ole Gunderson (1,362,292) can
hardly be considered in the light of a serious reference, in
view of its glaring fallacies. Heretofore, the force of
gravity was found more than adequate for holding the machine
down but the inventor does not seem to appreciate this fact
and resorts to the use of a tree stump or some heavy object.

Upon starting and speeding up the motor, the hold is released and "the aeroplane rises along a substantially vertical line up which it is pulled by the combined action of the two propellers. When the desired altitude has been attained, the operator through his controls puts the machines on an even keel and continues his flight as usual." The passage which I have underlined, would be amazing if it were not a reiteration of statements repeatedly made by men of science and technical experts during the past forty years. That horizontal flight of a helicopter could be effected simply by tilting the axis of the propeller was one of the errors pointed out for the first by me in my patent specifications which also describe what must inevitably happen in such a case. The machine, deprived of the requisite sustentation, will plunge at once, being urged downward by a force equal to the excess of the weight over the vertical component of the axial propeller thrust, and theoretical consideration of stability show that the fall will take place through a great distance. Remembering that during any short interval of time these controls must be operated to suit the velocity, it is manifest that the maintenance of balance would be very difficult, if not impossible when, as in the instance considered, the speed is changing with great rapidity.

Moreover, the peril is increased by the physiological effect of the fall upon the aviator. He is supported by his rigid bone structure and a sudden vertical descent produces a displacement of the movable contents of his body with the result of causing nausea and dizziness, if not complete loss of consciousness. And even if he should prove equal to the task, it is not very likely that he would pass safely through the oscillations which, according to the theory set forth in my specifications, must necessarily occur and persist through a long period of time.

The patentee's scheme for terminating the flight is also misconceived and perilous. He says: "When a landing is to be made, the machine is steered to a point near the surface and then its nose turned upward, the speed of the propellers is retarded ----". The fallacy of this procedure is obvious but to appreciate it fully attention should be called to the fact that the thrust necessary to propel the machine horizontally under normal conditions is much smaller than that required in the operations of rising and descending, for, during these, besides the lifting effort barely sufficient to counteract the weight an additional and great force must be brought into play for vertical acceleration or deceleration of the mass. Now it is perfectly clear that if - at the moment the machine is righted and the planes cease to support - the already too small lifting force is further reduced by slowing down the propellers, a fall will be unavoidable which, even though it be from a small elevation, will be fraught with danger enhanced by horizontal velocity.

The patent granted to Albert F. Zahm described the invention of an expert of high attainments, thoroughly familiar with the general and mathematical theory of the aeroplane as well as its practical operation. It can not be passed upon lightly or brushed aside especially as he is represented by an attorney possessed of extensive knowledge in this very field. That the statements define accurately the improvements made by the patentee, there can be no doubt. But just because of the qualification of these experts, in scrutinizing the document carefully, it should be borne in mind that, as a rule, scientific men express their ideas with great precision; hence any errors or admissions found in their specification are of great significance and must be looked upon as important evidences.

This being granted it can be readily and convincingly shown that Zahn did not have the remotest idea of my process and apparatus and that his machine was inoperative in the sense of my invention. I shall not enter into an extended analysis of the specification but confine myself to a few passages which, I believe, will be sufficient to establish these facts.

On page 2, lines 56 to 60, he says: "As above pointed out, the weight of the motor units per h.p. should be minimized and reduced to at least 2 lbs. Otherwise operation of the craft as a helicopter would be impossible."

Here is an admission so direct and positive as to dispense with the necessity of any further proof of my contention, for any well grounded mechanical engineer, who would have a clear knowledge of my improvements, could not fail to perceive that it is not the rated performance per pound of weight of the motor, but the characteristics of the motor utilized and its concurrent and corresponding utilization to maintain the lifting force sensibly constant, which are the determining factors. The patentee is one of the best informed men in the profession, hence in expressing himself as above, he furnishes uncontrovertible evidence of complete absence of knowledge of those constructive and operative principles on which my invention is based, as the same can be carried out successfully in practice with a motor weighing four or even six pounds per horse power provided that the engine has the great overload capacity required in the operations of starting, transposition and landing as described in my patent specifications under consideration.

Zahn shows, moreover, that he is entirely under the spell of the common erroneous opinion which ignores the fundamental law of propulsion discovered by Rankine. Rankine's law proves with mathematical certitude that a helicopter,

equipped with a suitable propeller, could be made to rise vertically and descend slowly if the weight of the motor were ten pounds per horse power, or more!!! But, contrary to the prevailing ideas, it could attain but a relatively small horizontal speed and this would be the case even if the body resistance be infinitely small. A great propeller thrust implies the propulsion of a big mass of air with small velocity and a machine of this kind could never exceed, in horizontal flight, a component of this velocity the magnitude of which would depend on the angle of inclination. In the ordinary aeroplane a comparatively small mass of air is propelled with great velocity hence, in conformity with the law of Rankine, the propeller thrust obtainable with an engine of given weight must be much smaller than required in a helicopter.

The patentee Zahn has, however, not only admitted his entire unacquaintance with my process and cardinal features of my apparatus but proves by his own statements that the device he proposes to construct would be for purposes of my process inoperative. Thus, on page 2, lines 25 to 30, he says: "The pitch of the propellers is such that sufficient vertical lift is realized from the propellers when revolving in a horizontal plane to bodily lift the machine on a vertical line (or at a slight inclination) into the air." And on the same page, lines 60 to 64: "With the weight of the motor units thus reduced and the pitch of the propellers designed as indicated sufficient vertical lift can be realized to lift the machine bodily up into the air."

The words in these passages which I have underlined are significant showing as they do conclusively that the device could not be successfully employed in the carrying out of my process. Just sufficient lift to raise the machine

vertically or at a slight angle would be far from adequate for the thrust requirements in the operations of transposition and also in vertical acceleration and deceleration of the mass even if, by a miracle, the air happened to be perfectly quiescent.

Then again, the density of the air diminishes rapidly with increasing height, so that a distance of a mile from the ground the propeller thrust is reduced to about two thirds of its initial value. Under the provisions made ^{by Zahn} the machine would stall at a certain much smaller height, and would tumble down if it encountered but a slight downward air current.

On page 2, lines 105 to 110 the patentee contradicts himself when he states: "With the motors developing maximum power, stalling in mid air is impossible, for as the machine is swung into an acute angle to the vertical, the thrust value of the propellers is such that a direct vertical climb rather than a falling back, as heretofore, results." The words I have underlined violate the earlier assumption that the motors are capable only to lift the machine vertically or "at a slight inclination". The reduction of the propeller pitch is evidently such as to ^{so} reduce the vertical velocity of ascent ^{so} as to necessitate placement of the rudders in the propeller slipstreams to exercise any control at all. But the only ^{way} the machine might be made to rise and transpose is to increase the propeller thrust as I have specified. But no suggestion whatever of such a procedure is made and the device is admittedly incapable of fulfilling the requirements. On the contrary, it is explicitly stated on page 2, lines 65 and 66 that the rise is effected "by simply tilting the nose end of the machine upwardly" and it can be inferred with certitude that it is intended to accomplish the descent in the same manner. Nowhere is the very great "concurrent" and "corresponding" increase of thrust necessary to maintain the

the lifting force "sensibly constant" even hinted at.

Throughout the specification it is unmistakable that the patentee has in mind only the elements of an ordinary aeroplane and not the remotest thought of the elements of an entirely new type of machine I have devised.

Zahn's conception that the real obstacle in the way of the success of the helicopter and the helicopter aeroplane was an excessive weight ~~of~~^{per} horse power of the motor, is erroneous, as I have shown. Nor does the method of reduction of this weight to two pounds per H. P., or to such other point that with a reduced pitch of propellers and placement of rudders in the slip stream the vehicle can rise, remove this obstacle, not to mention the real obstacle.

The real obstacle has been the weak and delicate equilibrium and the tremendous and uncontrollable surging incident to its disturbance during transposition of attitude of the machine. I have removed it by the method of "concurrently" and "correspondingly" increasing the thrust with change of attitude from and toward vertical, in such manner as to maintain the lifting force "sensibly constant". I have provided for the practice of the method by inventing an apparatus combination including a motor of truly enormous capacity for overload, a motor whose normal continuous load capacity is adapted to normal vertical and horizontal flight requirements for thrust, a motor whose overload capacity is adapted not only to the enormous thrust requirements of change in attitude but also to give adequate velocity on the flight path at all times to insure perfect control.

59 The reciprocating motors of the constant volume type used in aviation today are utterly incapable of such adaptation. These are the motors Zahn and Gunderson use. Their very maximum power is required for either vertical or horizontal flight. They have no overload capacity whatever.

(8)

This is characteristic of the constant volume type of motor, the capacity of which is absolutely dependent on the volume, the cubic contents of the motor cylinders. Even if it had the overload capacity, its character and dimensional limitations are such that overheating and overstrain would utterly wreck it.

The motor of my invention is characterized by the feasibility of substantially unlimited variation of both volume and pressure during operation. It can be given tremendous overload capacity. Its character and dimensional limitations permit overload for long periods without harm to the motor. Zahn and Gunderson did not see the real obstacle in the way, could not, therefore, and did not invent the method to overcome it, and did not invent any apparatus by which this method may be practiced. To my knowledge motors of two pounds per H. P. and less have been available for over ten years. Zahn predicated his invention upon them. It is significant that though there has been great need for machines of this type, nearly ten years have elapsed since Zahn filed the application for his patent without the success of any such machine.

And further deponent says not.

Nikolai Test

Sworn to and subscribed before me this 16th day
of July 1926.

Geo. B. O'Keefe
Notary Public

My Commission Expires Mar 6 1927

60

IN THE UNITED STATES PATENT OFFICE

In the matter of the applications
for Letters Patent in the name of

NIKOLA TESLA

Ser. No. 499,518 - Apparatus for Aerial Transportation

Ser. No. 499,519 - Method of Aerial Transportation



SUMMARY OF BRIEF

- I. This invention relates to the hitherto unsuccessful class of helicopters, helicopter aeroplanes and the like.
- II. Mr. Tesla's studies showed him the root of the trouble was unstable equilibrium and ungovernable surgings during the transposition stages from vertical to horizontal flight and vice versa.
- III. Mr. Tesla invented a new method of operation which eliminates entirely this root trouble. The method which consists in increasing (not as heretofore decreasing) the thrust of the propeller "concurrently" and "correspondingly" with increase of inclination of the thrust axis away from, (and conversely toward) the vertical axis, and thereby maintaining the lifting force (whatever its adjusted value) sensibly constant.
- IV. The earlier inventors had utterly no conception of either the root trouble or its remedy, this new method of operation.
- V. The earlier inventors had no apparatus by means of which, even had it been conceived, such a method could have been carried out.

Serial No. 499,518 and 499,519

VI. But this inventor has also invented an apparatus to carry out the method. The apparatus is a new combination of elements involving an old but hitherto unutilized motor, a liquid hydrocarbon motor operating under an extremely wide a variation of volume and pressure and having an unlimited capacity for temporary overload -- a motor whose normal continuous load capacity is adapted to normal flight requirements, but whose overload capacity is adapted to that manifoldly increased requirement of power necessary to effect transposition from vertical to horizontal flight and vice versa under perfect equilibrium and control.

VII. This new combination is as soundly patentable under our laws as is any other new combination. The fact that one of its elements is an hitherto known but not used motor does not make the case in any wise different from the case of the known but hitherto unused mechanical movement or other element in a combination. It is just as proper for a motor to form an element in a patentable combination, to impart patentability, as for any other element or mechanism so to do. The criterion is not the element, the mechanism, the motor. The criterion is the new result!!!

VIII. Selden succeeded in producing the governable automobile of today. He was granted on it combination claims involving the kind of motor as an element. The courts sustained their patentability.

The Wright Brothers succeeded in producing a controllable aeroplane. They were granted a patent involving the elements used for its control. The courts sustained the patent.

Serial No. 499,518 and 499,519

(3)

Mr. Tesla has produced a method and apparatus for the controlled flight of the helicopter and helicopter aeroplane. He asks that there be granted him the combination claims setting forth the elements of this control. The British and other Patent Offices have already granted such claims. There would appear to be no pertinent reason why our own Patent Office may not do so.

Respectfully submitted,


Attorney for Applicant

Philadelphia, Pa.
July 16, 1926.



IN THE UNITED STATES PATENT OFFICE

In re Application of

NIKOLA TESLA

Ser. No. 499,519

Filed - Sept. 9, 1921

METHOD OF AERIAL TRANSPORTATION

TO THE HONORABLE BOARD OF EXAMINERS-IN-CHIEF:

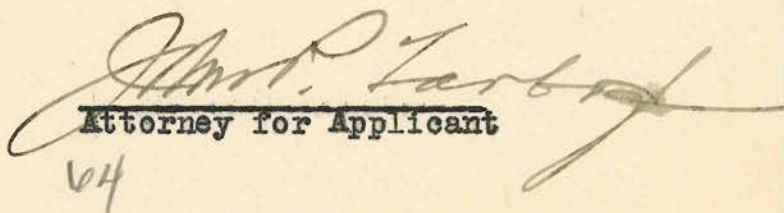
Permission is requested to add the following claim:

The method of controlling the flight of a heavier-than-air vehicle adapted for substantially vertical and horizontal propulsion and change from one to the other attitude by a system producing thrust in fixed relation to the principal axis of the machine, which method consists in concurrently and correspondingly varying the thrust so as to keep the lifting force sensibly constant during changes of attitude.

REMARKS

This claim is the result of the careful analytical study which applicant's present attorney has just now been able to give this application. The need for it to round out the ~~note~~ of protection to which applicant is entitled is self-evident from the reading of the analysis which has been presented to the Board. When this analysis is understood, the claims speak for themselves.

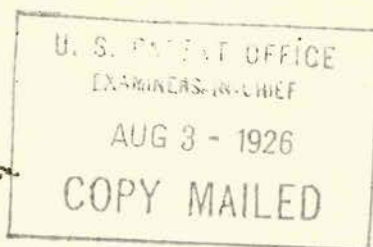
Respectfully submitted,


Attorney for Applicant
64

Philadelphia, Pa.
July 16, 1926.

EGB.

Hearing:
July 7, 1926.



Appeal No. 13,354. U. S. Patent Office. Aug. 3, 1926.

Before the Examiners-in-Chief, on Appeal.

Application of Nikola Tesla for a patent for an improvement in Method of Aerial Transportation, filed Sept. 9, 1921, Serial No. 499,519.

Mr. John P. Tarbox, attorney for appellant.

Affidavits having been filed in this case since the appeal was taken, the application is hereby remanded to the primary examiner, under the provisions of Rule 138, for reconsideration under the provisions of Rule 76, and for report to the Examiners-in-Chief as to his conclusions thereon.

W. S. Buchanan
Frank C. Skinner
G. A. Ide
Examiners-in-Chief.

DEPARTMENT OF COMMERCE,
United States Patent Office,
Washington, D. C.

In re application
Nikola Tesla,
Serial No. 499,519,
Filed Sept. 9, 1921, for
Method of Aerial Transportation.



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BEFORE THE BOARD ON APPEAL.

EXAMINER'S STATEMENT.

This application has been remanded to the primary examiner under the provisions of Rule 138 for reconsideration in connection with an affidavit under Rule 76.

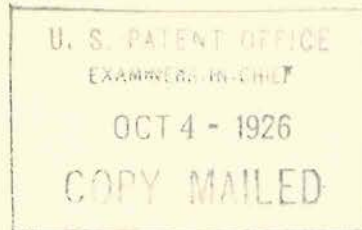
The examiner is of the opinion that the affidavits fail to point out any tangible reason why the references do not anticipate the rejected claims and the reasons stated in the examiner's statement appear to apply with equal force to the proposed claim.

J. H. Colwell
Examiner.

Decision.

EGB.

Hearing:
July 7, 1926.



Appeal No. 13,354. U. S. Patent Office. Oct. 4, 1926.

Before the Examiners-in-Chief, on Appeal.

Application of Nikola Tesla for a patent for an improvement in Method of Aerial Transportation, filed Sept. 9, 1921, Serial No. 499,519.

Mr. John P. Tarbox, attorney for appellant.

This is an appeal from the final rejection of claims 1 to 5 inclusive of which the following will serve as an example:

1. The hereinbefore described method of aeroplane transportation which consists in developing by the propelling device a vertical thrust in excess of the normal, causing thereby the machine to rise in an approximately vertical direction, tilting it and simultaneously increasing the power of the motor and thereby the propeller thrust, then gradually reducing the power and thrust as forward speed is gained and the planes take up the load, thus maintaining the lifting force sensibly constant during flight, tilting the machine back to its original position and at the same time increasing the power of the motor and thrust of the propeller and effecting a landing under the restraining action of the same.

The references are:

Gunderson, 1,362,293, Dec. 14, 1920.
Zahm, - 1,358,603, Nov. 9, 1920.

67

The invention relates to a method of operating apparatus of the combined helicopter and aeroplane type. By this method the apparatus is driven first vertically, then tilted and driven horizontally by the same propeller. The force of sustentation is derived during the vertical ascent from the propeller but during the horizontal flight it is derived from the aeroplanes which are then propelled horizontally by the prime mover.

Appellant contends in his brief that the trouble heretofore with devices of this class has been the "unstable equilibrium and ungovernable surgings during the transposition stage from vertical to horizontal flight and vice versa" and that this trouble is eliminated in his new method of operation which consists, -

"in increasing (not as heretofore decreasing) the thrust of the propeller "concurrently" and "correspondingly" with increase of inclination of the thrust axis away from, (and conversely toward) the vertical axis, and thereby maintaining the lifting force (whatever its adjusted value) sensibly constant."

Appellant states in his specification (page 9) that he is able to carry out his method, requiring an increased thrust of the propeller at the critical period, by means of the improved motor having great overload capacity and forming the subject matter of his patent No. 1,061,206.

The examiner rejected the claims on the patents to Zahm and Gunderson, which he states "show the method

of starting off with the propellers in a horizontal plane and describe how the airplane is tilted to a horizontal plane by means of the controlling means."

This much of appellant's method is unquestionably disclosed in the references. The **step** of appellant's method consisting "in varying the power of the motor and thereby the thrust of the propeller according to the inclination of its axis so as to maintain the lifting force sensibly constant during the forward flight", as set forth in claim 2 and in equivalent language in claims 1, 4 and 5, is not disclosed in the references. This step, however, the examiner considers obvious and in his statement says, -

"In both Gunderson and Zahm, the examiner holds the necessary power to maintain the desired flight will be used. Therefore, since it is well known in the art that less power is necessary when the supporting surfaces are in action than when they are not, it is held that nothing novel and patentable resides in the variations in the propelling power as claimed."

We are unable to agree with this conclusion of the examiner. As noted above appellant's method provides for a great increase in thrust to maintain the lifting force which otherwise decreases as the machine is tilted due to the fact that only the vertical component of the force of the propeller is then exerting a lifting force and the sustaining force of the wings is small until a forward headway is attained. Zahm makes no mention of this problem or its solution. So far as referred to in

the Gunderson patent (page 2, line 19) Gunderson proposes to retard the speed of the propellers during the turning of the craft instead of accelerating it.

Claim 3 which calls for "varying the speed of the motor and thereby the thrust of the propeller concurrently with the changes of inclination of the axis of the device" does not specify whether the speed is increased or decreased and consequently is so broad as to read on the Gunderson disclosure. Claims 2 and 5 which add "so as to maintain the lifting force sensibly constant during forward flight" are thought to be limited to appellant's invention. Claims 1 and 4 are still more specific. In our opinion the subject matter of claims 1, 2, 4 and 5 is novel, unobvious and patentable.

The decision of the examiner is affirmed as to claim 3 and is reversed as to claims 1, 2, 4 and 5.

W. S. Buchanan
Sidney F. Smith
J. R. Lee
Examiners-in-Chief.



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C #20

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U. S. PATENT OFFICE

IN THE UNITED STATES PATENT OFFICE

DIV. XII

OCT 4 1927

U. S. PATENT OFFICE

In re Application of

NIKOLA TESLA

METHOD of AERIAL
TRANSPORTATION

Serial No. 499,519

Filed - September 9, 1921

Appeal No.

13,354

Hon. Commissioner of Patents,
Washington, D. C.

Sir:-

In response to the statement of October 4,
1926 of the Examiners-in-Chief in the above entitled case,
please cancel claim 3.

It is believed that this case is now ready
for allowance and such action is respectfully requested
within an early date.

Respectfully submitted,

John P. Harbo
Attorney for Applicant

Philadelphia, Pa.
September 27, 1927

DC

70



Fig. 1.

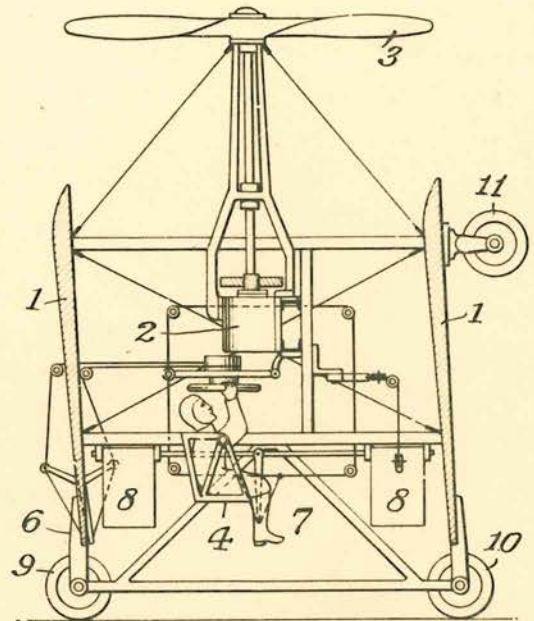


Fig. 2.

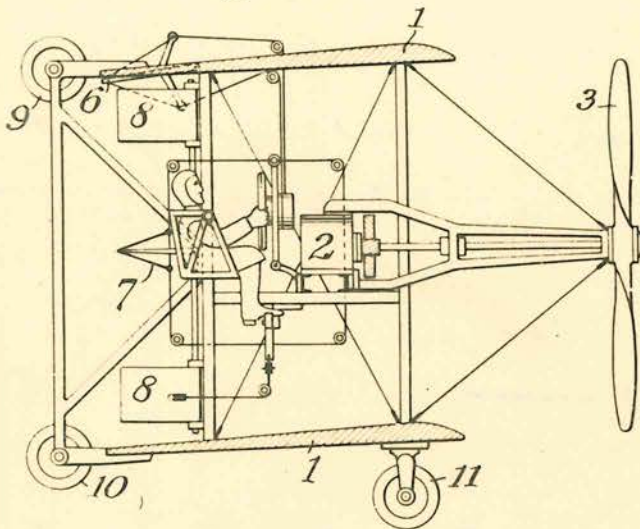
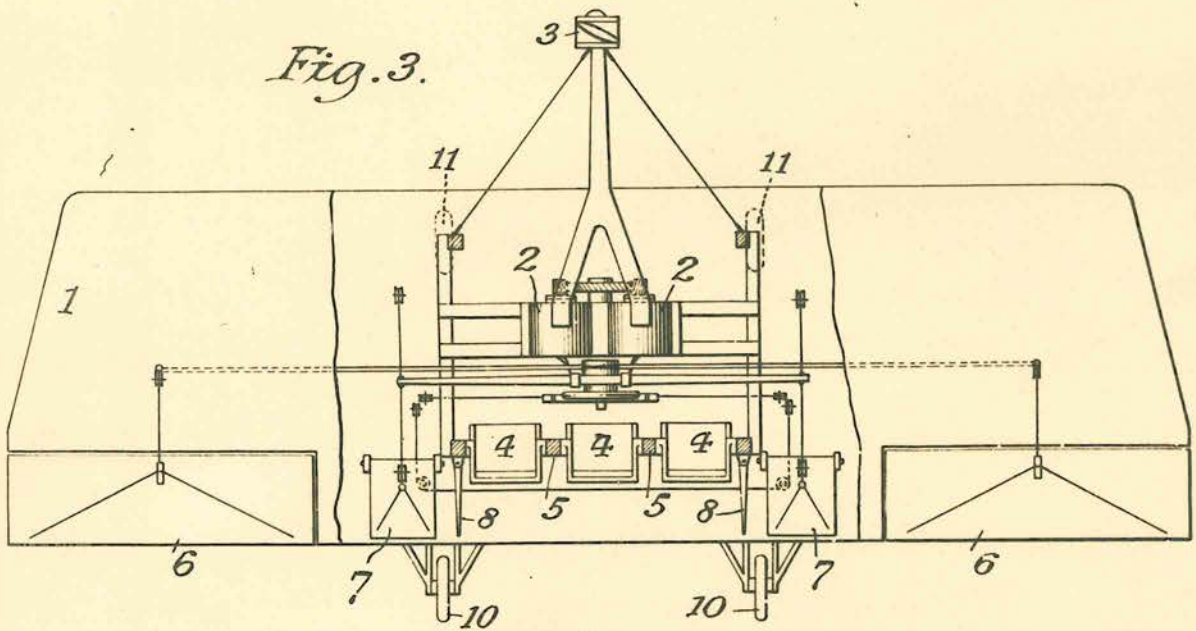


Fig. 3.



Nikola Tesla INVENTOR
BY Rev. Mr. Corbin & Hayward ATTORNEYS.

Div. 22

DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE
WASHINGTON

October 12, 1927.

Nickola Tesla,

Your APPLICATION for a patent for an IMPROVEMENT in

Method of Aerial Transportation,

filed Sept. 9, 1921 has been examined and ALLOWED with 4 claims.

The final fee, TWENTY DOLLARS, WITH \$1 ADDITIONAL FOR EACH CLAIM ALLOWED IN EXCESS OF 20, must be paid not later than SIX MONTHS from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld, but the application may be renewed within one year after the date of the original notice with a renewal fee of \$20 and \$1 additional for each claim in excess of 20.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be sent, DISTINCTLY AND PLAINLY WRITTEN, the name of the INVENTOR, TITLE OF THE INVENTION, AND SERIAL NUMBER AS ABOVE GIVEN, DATE OF ALLOWANCE (which is the date of this circular), DATE OF FILING, and, if assigned, the NAMES OF THE ASSIGNEES.

If it is desired to have the patent issue to an ASSIGNEE OR ASSIGNEES, an assignment containing a REQUEST to that effect, together with the FEE for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of TEN CENTS EACH. The money should accompany the order. Postage stamps will not be received.

The final fee will NOT be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

NOTICE.—WHEN THE NUMBER OF CLAIMS ALLOWED IS IN EXCESS OF 20, NO SUM LESS THAN \$20 PLUS \$1 ADDITIONAL FOR EACH CLAIM IN EXCESS OF TWENTY CAN BE ACCEPTED AS THE FINAL FEE.

Respectfully,

Thomas E. Robertson

Commissioner of Patents.

John P. Tarbos,
5026 Erringer Place,
Philadelphia, Pa.

IN REMITTING THE FINAL FEE GIVE THE SERIAL NUMBER AT THE HEAD OF THIS NOTICE.

UNCERTIFIED CHECKS WILL NOT BE ACCEPTED.

\$20 received as

the final fee in the application of

Nikola Tesla

Serial No. 499 519

for

applied from a composite letter No. 230598

received Dec. 7-27

from Jno P Tarbot

which is on file in the Chief Clerk's room.

John Farns

Chief of Issue and Gazette Division.

Fig. 2.

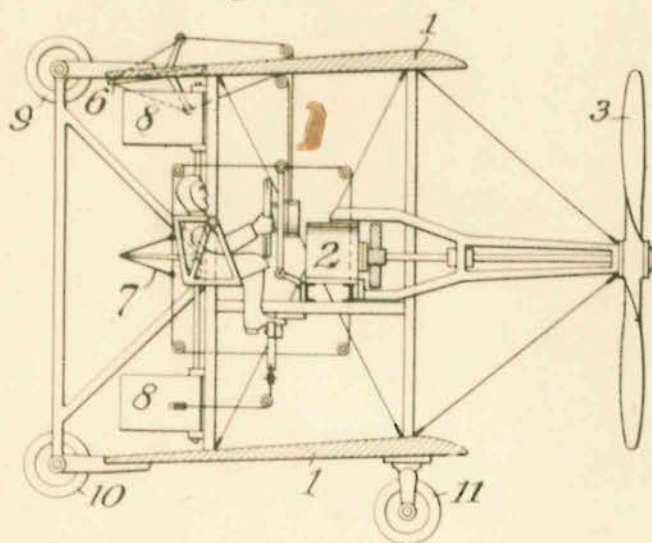


Fig. 1.

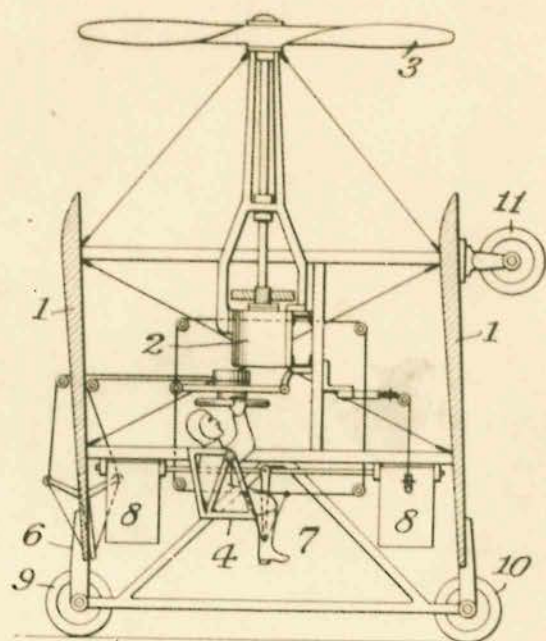
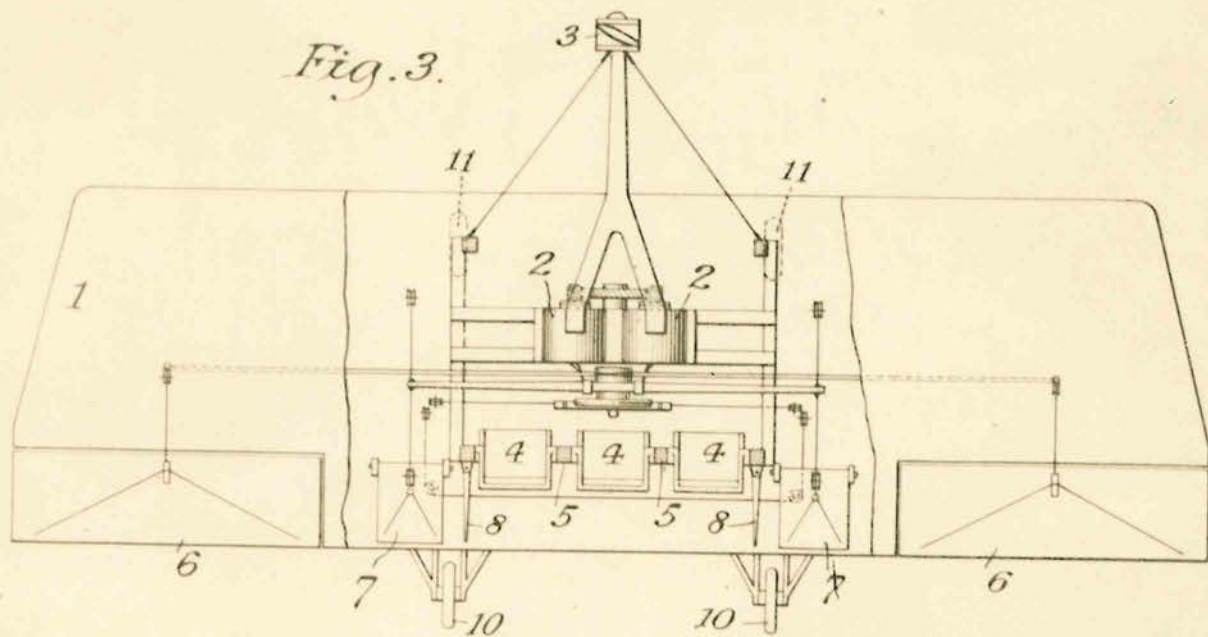


Fig. 3.



INVENTOR
Nikola Tesla
BY
Rev. Mr. Coker & Haywood
ATTORNEYS

244 14

Serial No. 499519

1 Sheet - Sheet

65-2
217

Fig. 2.

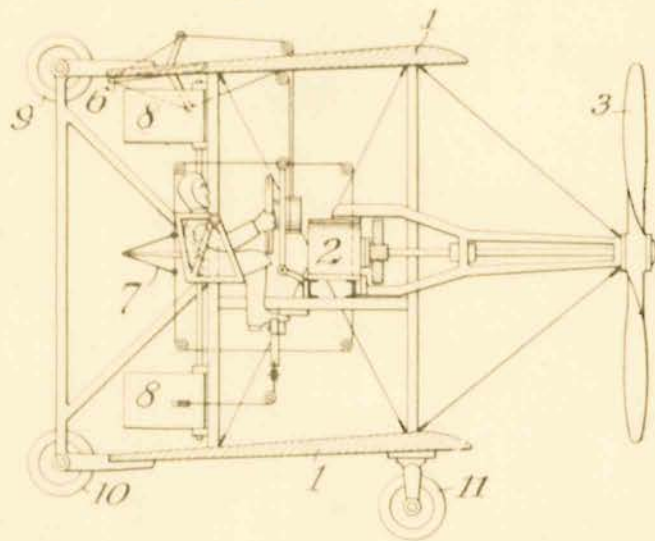


Fig. 1.

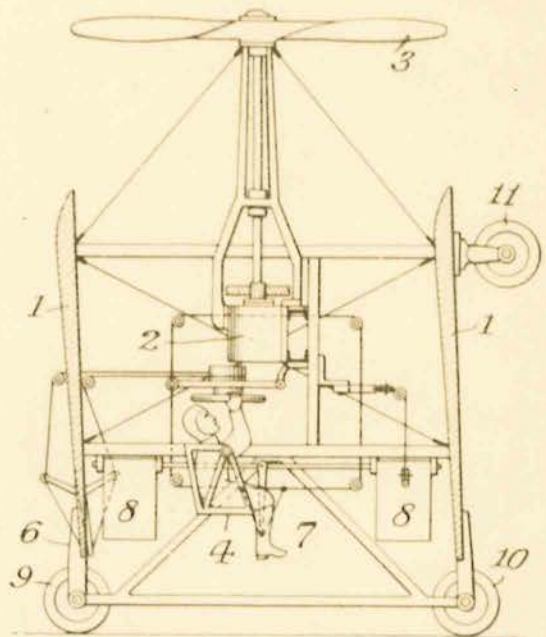
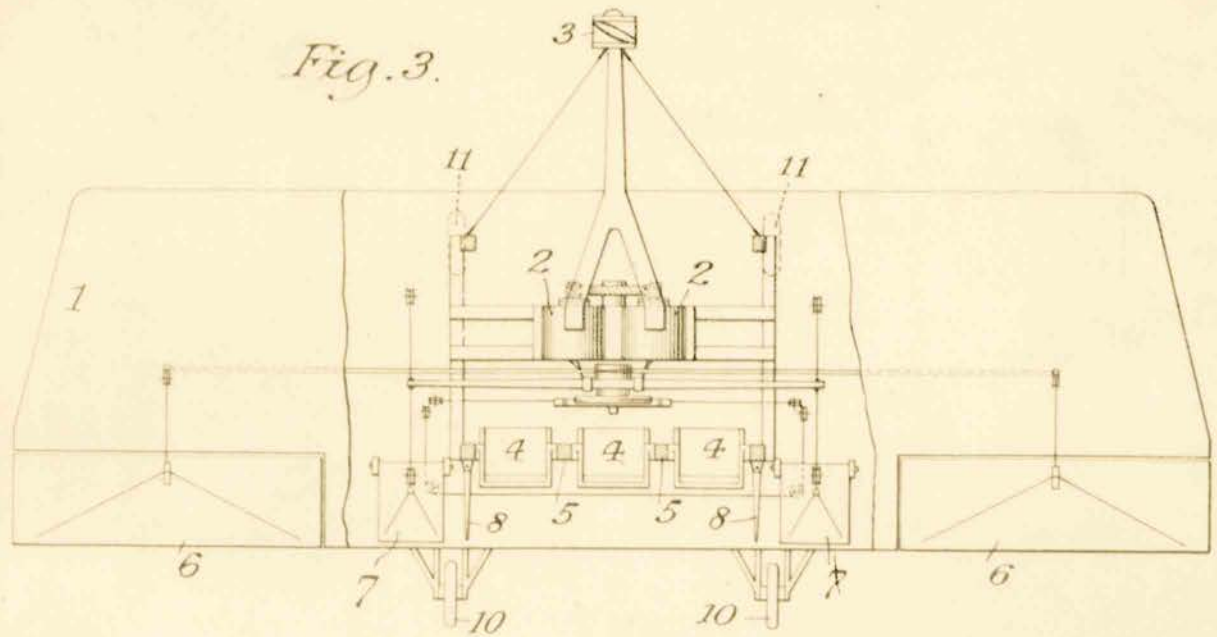


Fig. 3.



INVENTOR
Nikola Tesla
BY *Rev. Mr. Peter H. ...*
ATTORNEY 3.

FIG. 1.

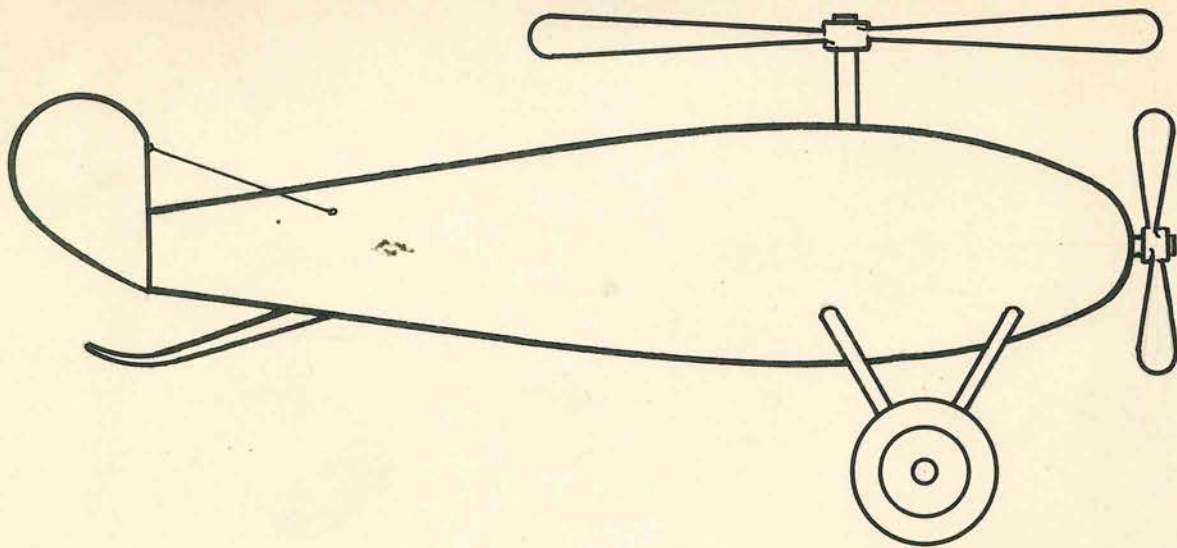


FIG. 3.

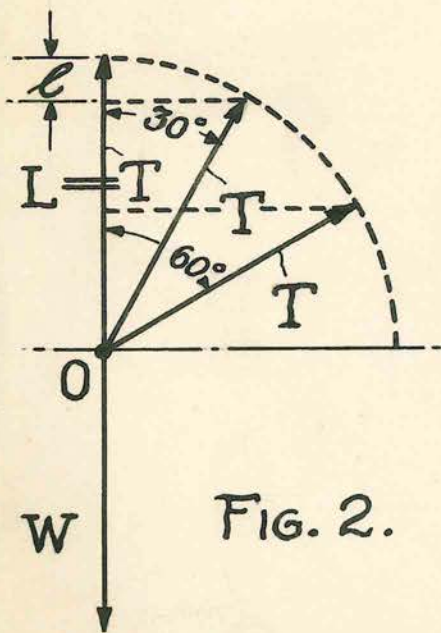
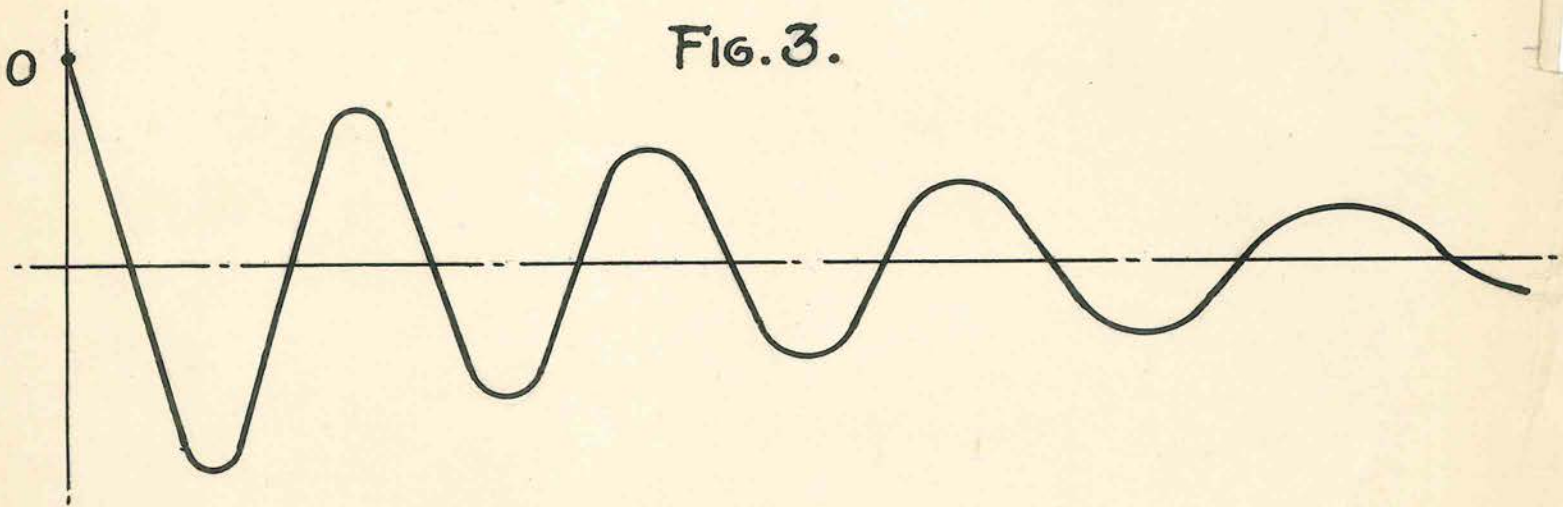


FIG. 2.

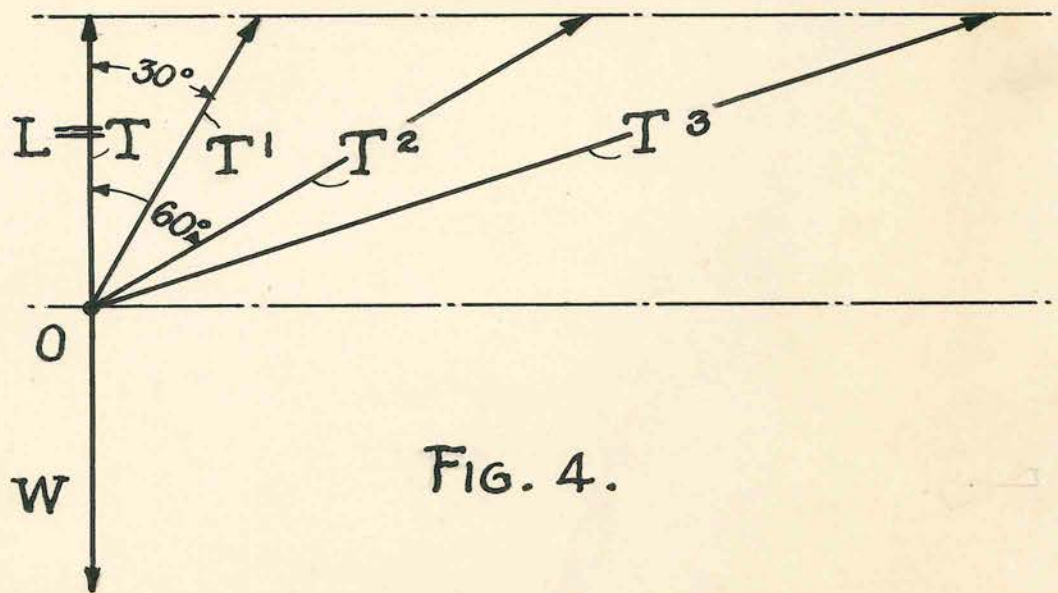


FIG. 4.

FIG. 1.

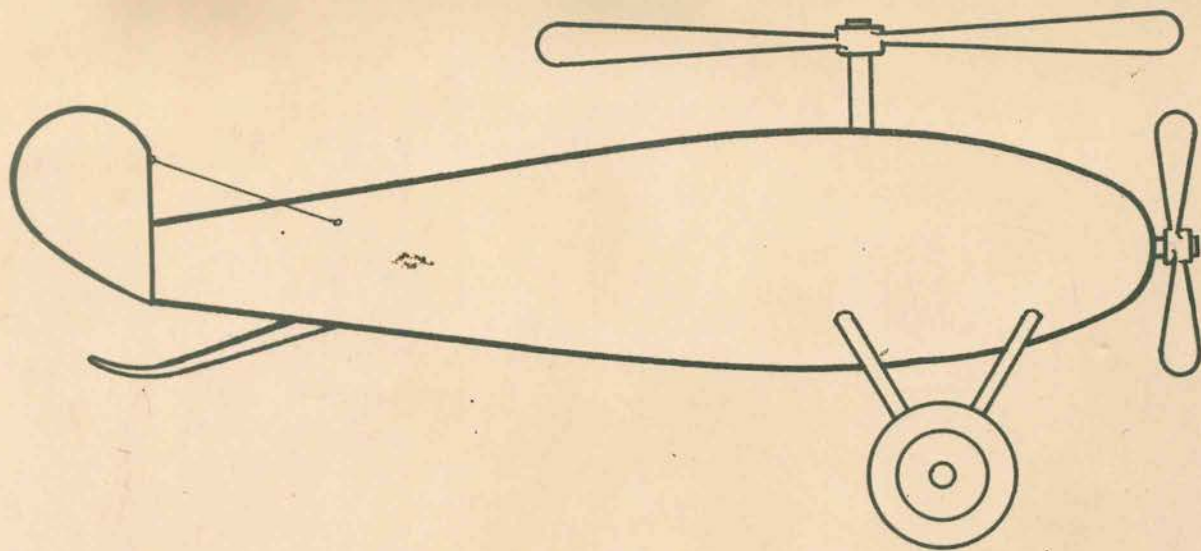


FIG. 3.

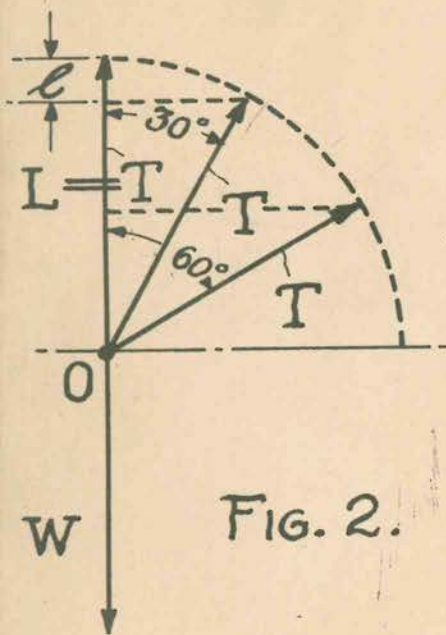
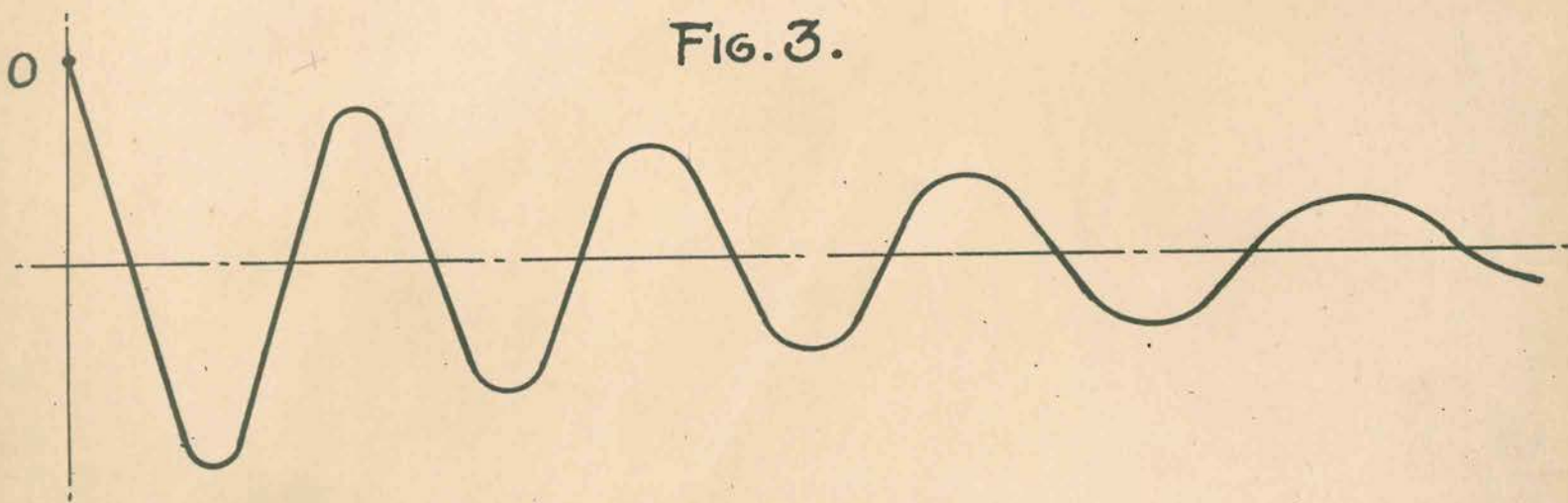


FIG. 2.

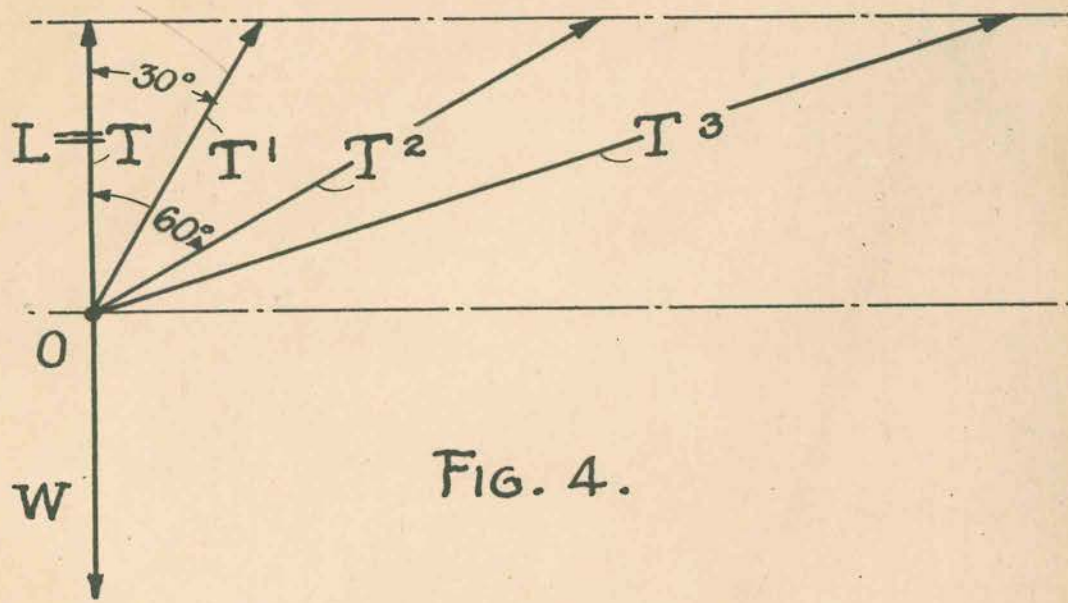


FIG. 4.

O. GUNDERSON.
AEROPLANE.
APPLICATION FILED MAR. 23, 1920.

1,362,292.

Patented Dec. 14, 1920.

Fig. 1.

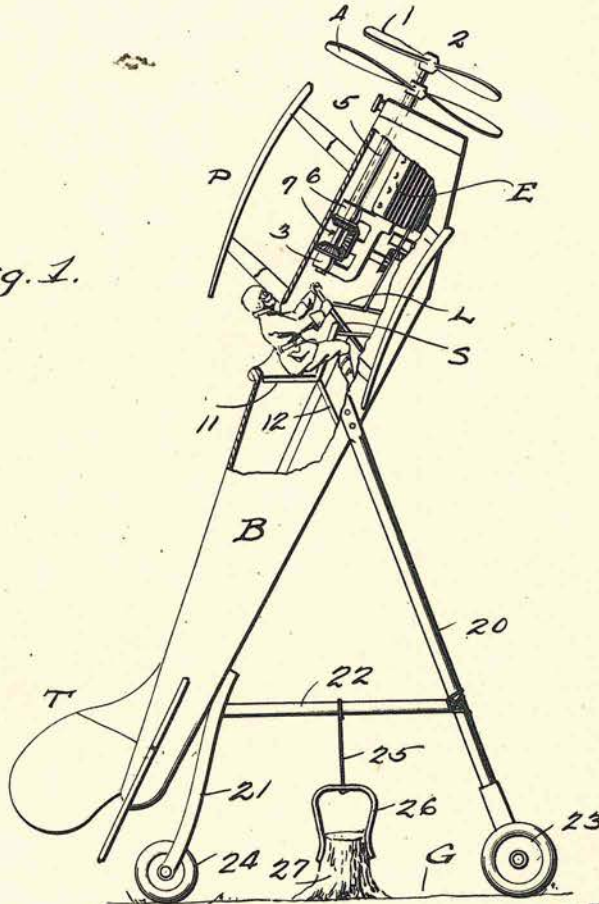
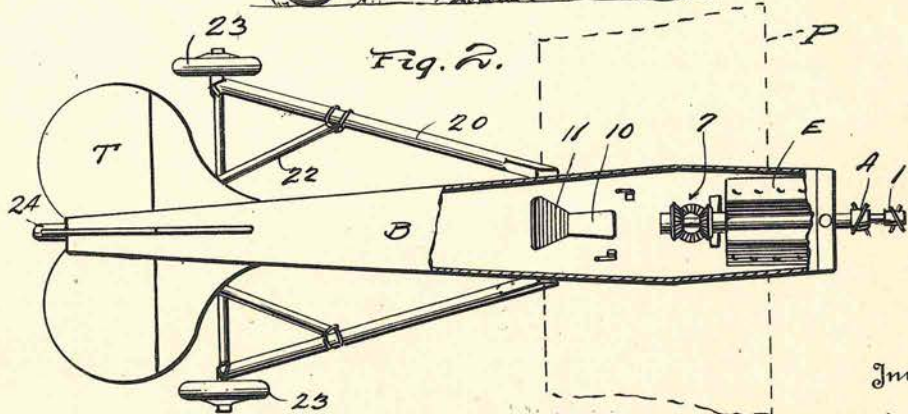


Fig. 2.



Inventor

Ole Gunderson

Witness
B. W. W. W.

N. L. Collamer

By

[Signature]

Attorney

UNITED STATES PATENT OFFICE.

OLE GUNDERSON, OF SCHENECTADY, NEW YORK.

AEROPLANE.

1,362,292.

Specification of Letters Patent.

Patented Dec. 14, 1920.

Application filed March 23, 1920. Serial No. 368,005.

To all whom it may concern:

Be it known that I, OLE GUNDERSON, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Aeroplanes; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to aeronautics, and more especially to launching and landing devices; and the object of the same is primarily to construct a flying machine which is designed and intended to rise along a substantially vertical line under the impulses of its own propellers.

In carrying out this object, one feature of the invention is the arrangement of its supporting chassis.

Another feature is the special seat for the driver.

Another feature is the special anchor.

Details of the invention as applied to any ordinary biplane are set forth below and shown in the drawings wherein:

Figure 1 is a side elevation of the machine about to ascend.

Fig. 2 is a plan view of the machine in flight, the planes being dotted only.

The body of the machine is broadly designated by the letter B, P are the planes, T the tails controlled by a steering device or stick S, and E the motor or engine controlled by a lever L; and no novelty is claimed for the parts mentioned.

The driving mechanism in the present case consists of a relatively small propeller 1 having two blades and mounted on a shaft 2 which rotates in a bearing 3, and a relatively large two-bladed propeller 4 mounted on a sleeve 5 surrounding the shaft 2 and in its own bearing 6, this propeller having its blades pitched and therefore as a whole rotating oppositely to the other and in a plane a little distance from it. Power is communicated from the motor or engine E to the shaft and sleeve in any suitable manner, as for instance by the bevel gearing broadly indicated at 7 in Fig. 1.

The drawings show the elements L and S for controlling the engine and for steering, and these elements will stand within reach of an operator mounted on his seat. The latter in this case is specially constructed,

having a bottom 10 and a back 11 at about right angles to it, and both being rather narrow as shown in Fig. 2, the seat being mounted on standards or supports 12 which hold it rigid with the body no matter what position the latter assumes. Ordinarily the driver will sit on the seat bottom 10, but when ascending or starting along a practically vertical line he will slide back and sit on the seatback 11 as indicated in Fig. 1, and the bottom should be rather narrow so that his legs can pass astride it at this time. The harness for holding him in place will be constructed with a view to permitting him to shift his position as thus suggested.

The launching and landing devices employed in connection with the machine as thus described are specially constructed in order that the body B will stand almost vertical when the base of the chassis rests on the ground. Said chassis is herein shown as having a pair of front legs 20 leading downward and rearward from the body B and diverging from each other, and a single rear leg 21 leading back from the body to a point beyond the tails, or at least to such point that it will hold the tails off the ground; and 22 designates truss rods for bracing the legs. This chassis may have for its base any suitable supports such as skids, shoes, pontoons, or wheels 23 and 24 as shown; but it is important that, whatever the form taken by the supports, the base of the chassis shall stand nearly at right angles to the length of the body. Therefore when said base (the wheels as shown) rests on the ground, the body B stands upright on the ground G, and by preference inclined forward a little from a strictly vertical line.

In connection with this structure I preferably make use of an anchor, herein shown as composed of a rope 25 connected with some part of the chassis and hanging therefrom, and a spring clip 26 carried by the rope and adapted to be engaged with some fixed object such as the stump 27 herein illustrated, although of course any heavy object such as a stone or perhaps an attendant would answer. The purpose of the anchor is to hold the machine upright on its base ready to start, and the spring clip will slip off the object 27 (or be released by the attendant) when the start is made.

In launching a machine as thus constructed, it is stood on the base of its chassis as seen in Fig. 1 and anchored if an anchor

is used. The operator now climbs to his seat and assumes about the position shown, sitting on the seat-back 11 which at this time is nearly horizontal. The motor is started and sped up, and eventually the propellers attain sufficient speed to lift the machine off the earth. As soon as clip 26 pulls off the object 27, the retarding effect of the anchor no longer prevails, and the aeroplane rises along a substantially vertical line up which it is pulled by the combined action of the two propellers. When the desired altitude has been attained, the operator through his controls puts the machine on an even keel and continues his flight as usual.

When a landing is to be made, the machine is steered to a point near the surface and then its nose turned upward, the speed of the propellers is retarded and the momentum of the machine soon ceases, and then by proper control the operator can permit the machine to settle tail-first until he lands on the base of the chassis with the nose of the machine in the air and again in the position occupied at starting. In other words, launching is effected by use of a chassis which holds the machine with its nose upward, and employment of the motor and propellers; and landing is effected by a tail drive, while descent is retarded and controlled by the same propellers. It is obvious that the wheels 23 and 24 might be replaced by other forms of shoes, and even pontoons could be used at the base of the chassis so that the machine could rise from and alight upon the water.

What is claimed as new is:

1. In an aeroplane, a launching and landing chassis carried by the body with its base substantially at right angles to the length of such body, and anchoring mechanism adapted to make frictional engagement with some fixed object.

2. The combination with an aeroplane including a body and tails; of a chassis including a rear leg projecting from the body beyond the tails, fixed front legs, and supports on said legs producing a base for the chassis standing in a plane substantially at right angles to the length of the body.

3. The combination with an aeroplane including a body and tails; of a chassis including a rear leg projecting from the body beyond the tails, front legs projecting obliquely downward and rearward from the front of the body and diverging from each

other, braces for these legs, and wheels at the lower ends of all legs standing in a plane substantially at right angles to the length of the body.

4. The combination with an aeroplane including a body and tails; of a launching chassis including legs projecting obliquely from the front of the body, and beyond the tails from the rear of the body, and wheels on said legs in a plane substantially at right angles to the length of the body, and anchoring mechanism including a spring clip suspended from said chassis and adapted to make frictional engagement with some fixed object.

5. In an aeroplane, the combination with a body and its tails and driving mechanism, the controls, and a seat fixedly supported from the body adjacent the controls and including a narrow bottom and a back at right angles thereto; of a launching chassis carried by the body and with its base in a plane across the rear of the tails substantially at right angles to the length of the body.

6. In an aeroplane, the combination with a body and its tails and driving mechanism, the controls, and a seat fixedly supported from the body adjacent the controls and including a narrow bottom and a back at right angles thereto; of a launching chassis carried by the body for holding the latter substantially vertical with its tails above the surface, and anchoring mechanism including a rope connected with the body and a spring clip carried by the rope and adapted to engage a fixed object.

7. The combination with an aeroplane including a body and tails; of a chassis including a rear leg projecting from the body beyond the tails, front legs projecting obliquely rearward from the front of the body and diverging from each other, braces for the legs holding their lower ends in a plane substantially at right angles to the length of the body, and anchoring mechanism including a rope connected with the braces and means on said rope adapted to make frictional engagement with some fixed object.

In testimony whereof I affix my signature in the presence of two witnesses.

OLE GUNDERSON.

Witnesses:

M. K. KJOLSETH,
JACOB FRONDSSEN.

A. F. ZAHM.
HOVERING AEROPLANE.
APPLICATION FILED AUG. 10, 1917.

1,358,603.

Patented Nov. 9, 1920.

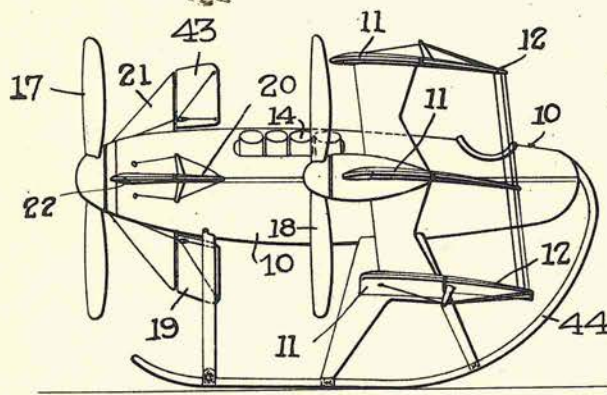


FIG. 1.

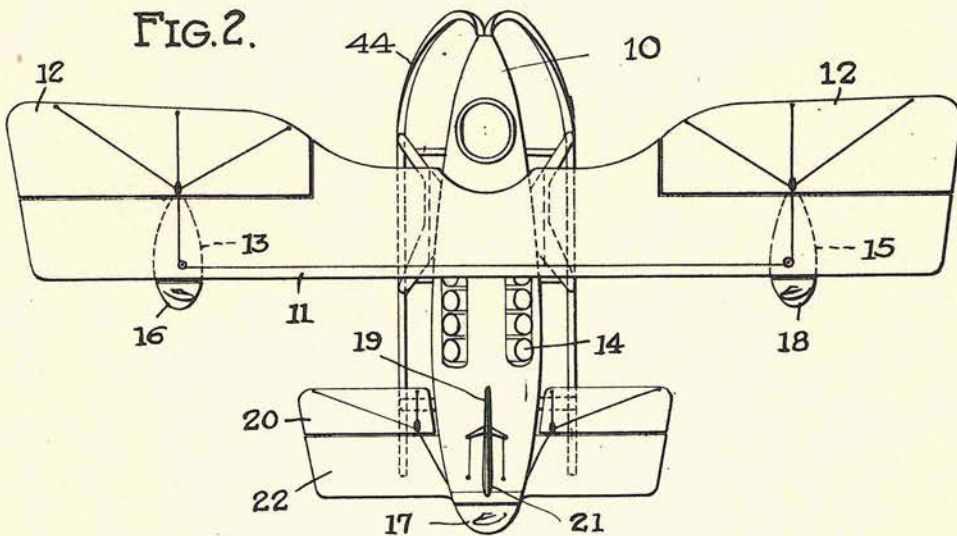


FIG. 2.

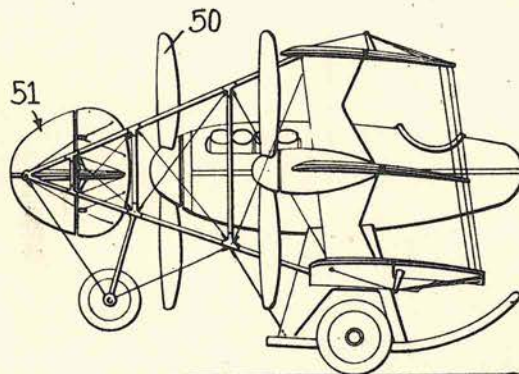


FIG. 3.

Inventor
ALBERT F. ZAHM.

John P. Starbo
Attorney

UNITED STATES PATENT OFFICE.

ALBERT F. ZAHM, OF WASHINGTON, DISTRICT OF COLUMBIA.

HOVERING AEROPLANE.

1,358,603.

Specification of Letters Patent.

Patented Nov. 9, 1920.

Application filed August 10, 1917. Serial No. 185,488.

To all whom it may concern:

Be it known that I, ALBERT F. ZAHM, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Hovering Aeroplanes, of which the following is a specification.

My invention relates to airplanes. It is capable of horizontal flight, volplaning and climbing, and under such conditions is supported wholly by air reaction upon one or more supporting surfaces of aerofoil form. It is further capable of vertical or nearly vertical flight and of hovering suspended, as it were, immovable in mid air. In starting it may be launched into the air without any or any substantial preliminary run, and if desired may alight under similar conditions. Briefly it may be described as of a construction such that the various characteristics of the conventional aeroplane are retained with the added characteristic of a helicopter.

A characteristic of the invention is the landing gear construction. The landing gear is preferably carried back from a point in advance of the transverse vertical plane of the center of gravity and curved upwardly and rearwardly whereby the machine can be rocked or tilted back sufficient to elevate its forward end. When thus positioned the machine can be started and the usual long preliminary run completely or almost completely eliminated.

In gaining vertical lift, with the nose end of the machine elevated, it is proposed to use a very light motor or motors in which the weight is reduced to two lbs. or less per h. p.; it being well known that a 300 h. p. motor of this type with a propeller properly designed will give an axial thrust of between 1500 and 2000 lbs. and weigh approximately 600 lbs. Preferably a multiple number of tractor propellers are used. These propellers are disposed in such relation to the sustaining surfaces that the propeller slip stream acts upon practically the full surface area as well as upon the controlling surfaces usually mounted at the wing tips and at the tail end of the machine. Through this

arrangement of all control surfaces in the propeller slip stream all controls are made effective whether traveling vertically, horizontally or at an angle or while hovering in the air. When traveling vertically sufficient vertical lift is realized from the propellers revolving in a horizontal or approximately horizontal plane to lift the machine bodily in a vertical line or at a slight inclination to the vertical. In attaining this result the high speed now attained in horizontal travel will in all probability be lessened somewhat owing to the fact that the propeller pitch will probably be lowered a considerable degree below the usual value.

The advantages of a machine of this type are that it can be launched vertically (for instance from the deck of a vessel) by merely tilting the nose of the machine upward; it can fly horizontally supported entirely by air reaction upon the aeroplane wings; it can be balanced regardless of the direction of flight by the conventional form of control surfaces; it can be made to climb at an acute angle to the vertical by simply deflecting the ailerons downwardly and simultaneously increasing the angle of incidence of the planes so that the air blast from the propellers reacts upon the planes; and it can be made to literally climb straight up without tilting the nose end of the machine upward through nullification of the thrust value in any suitable manner without a corresponding nullification of the lift value obtained through the reaction of air upon the wings. (This latter operation may be effected in a number of different ways; such for instance as holding the machine captive until it has risen into the air and then releasing it, or erecting standards at opposite sides of the fuselage and equipping the fuselage with lugs which extend out laterally so as to engage the standards at the rear). Other advantages will be hereinafter pointed out.

Of the drawings:

Figure 1 is a side elevation of a multiplane hovering machine having the characteristics of the invention claimed;

Fig. 2 is a front end elevation of the machine illustrated in Fig. 1; and

Fig. 3 is a side elevation of a modified type of machine having the same characteristics as the machine illustrated in said Figs. 1 and 2.

5 In Fig. 1 the body of fuselage of the machine is designated in its entirety by the numeral 10. It is equipped with a multiple number of superposed supporting surfaces 11, preferably three. These supporting surfaces are in turn equipped with interconnected ailerons 12 of relatively large area. The power plant comprises three motor units located respectively at the nose end of the fuselage and intermediate the supporting surfaces symmetrically out from the median fore and aft axis of the craft. Said motor units have been designated respectively 13, 14 and 15. The supports for the motor units 13 and 15 may be of any well known construction; preferably of sturdy type known in the art as the "pyramidal vee."

Each motor unit is equipped with a tractor screw or propeller of a determined pitch and size. The pitch of the propellers is such that sufficient vertical lift is realized from the propellers when revolving in a horizontal plane to bodily lift the machine on a vertical line (or at a slight inclination) into the air. The size of the propellers is such that the slip stream which flows back from the propellers is distributed substantially uniformly over approximately the entire supporting surface area and in such relation to the control surfaces that all said surfaces are effective whether the machine be traveling vertically, horizontally or at an angle. Said propellers have been designated respectively 16, 17 and 18.

40 At the tail end of the fuselage (which in the embodiment of the invention is the forward end) the usual rear controls are provided. Said controls include a vertical rudder 19, elevator flaps 20, vertical stabilizing fin 21, and horizontal stabilizing fin 22. Lateral directional control and vertical directional control are effected through manipulation of the vertical rudder 19 and the elevator flaps 20 respectively.

50 The landing gear or under-carriage is designated as 23. It will be hereinafter more particularly described. To minimize resistance the motor units 13 and 15 are separately inclosed in streamlined hoods or nacelles.

As above pointed out the weight of the motor units per h. p. should be minimized and reduced to at least 2 lbs. Otherwise operation of the craft as a helicopter would be impossible. With the weight of the motor units thus reduced and the pitch of the propellers designed as indicated sufficient vertical lift can be realized to lift the machine bodily up in the air. Flight may be started

under such conditions by simply tilting the nose end of the machine upwardly Canard style, in which event, although the climb or vertical lift be relatively slow, both directional control and lateral balance are effected through the usual manipulation of the various controls.

If vertical lift is desired in starting without changing the flying attitude of the machine, i. e. with the longitudinal axis of the fuselage extending horizontally; this may be done by nullifying the thrust value until sufficient lift is obtained through the reaction of the propeller slip stream upon the aeroplane wings to bodily lift the machine into the air. Any suitable means may be provided for obtaining this nullifying effect. Furthermore, when flown as a helicopter, a hovering action is obtainable by simply throttling the motors to such an extent that the lift value of the propellers equalizes the action of gravity.

If desired a single motor unit may be substituted for the three disclosed. If the machine is thus equipped the single motor unit should be located inside the fuselage and connected up with driving shafts which extend out right and left from the motor for suitable driving connection with propellers located respectively at opposite sides of the motor. In effect this arrangement is equivalent of the multiple power plant arrangement herein illustrated. The total weight of the craft however may in this way be reduced.

Preferably all parts of the machine are streamlined, and where possible, lightened to a maximum degree. In actual flight a machine constructed as herein set forth may fly alternately as a heavier-than-air flying machine and helicopter. With the motors developing maximum power stalling in mid air is impossible, for as the machine is swung into an acute angle to the vertical the thrust value of the propellers is such that a direct vertical climb rather than a falling back, as heretofore, results.

As intimated, in a Canard type machine the tail unit is forwardly located. Herein I have illustrated directional control surfaces placed both forwardly of and aft of the tractor propellers. In either case the fuselage or nacelle terminates just behind the pilot's seat to allow the lift of the horizontal rudder to point the nose end of the machine substantially vertically without ground interference.

A machine thus characterized may be launched into the air by elevating its nose end. In fact the launching of a machine of this type in the manner stated may be readily accomplished because of the fact that its center of gravity is well toward the rear and it may therefore be provided

Fig. 3 is a side elevation of a modified type of machine having the same characteristics as the machine illustrated in said Figs. 1 and 2.

In Fig. 1 the body of fuselage of the machine is designated in its entirety by the numeral 10. It is equipped with a multiple number of superposed supporting surfaces 11, preferably three. These supporting surfaces are in turn equipped with interconnected ailerons 12 of relatively large area. The power plant comprises three motor units located respectively at the nose end of the fuselage and intermediate the supporting surfaces symmetrically out from the median fore and aft axis of the craft. Said motor units have been designated respectively 13, 14 and 15. The supports for the motor units 13 and 15 may be of any well known construction; preferably of sturdy type known in the art as the "pyramidal vee."

Each motor unit is equipped with a tractor screw or propeller of a determined pitch and size. The pitch of the propellers is such that sufficient vertical lift is realized from the propellers when revolving in a horizontal plane to bodily lift the machine on a vertical line (or at a slight inclination) into the air. The size of the propellers is such that the slip stream which flows back from the propellers is distributed substantially uniformly over approximately the entire supporting surface area and in such relation to the control surfaces that all said surfaces are effective whether the machine be traveling vertically, horizontally or at an angle. Said propellers have been designated respectively 16, 17 and 18.

At the tail end of the fuselage (which in the embodiment of the invention is the forward end) the usual rear controls are provided. Said controls include a vertical rudder 19, elevator flaps 20, vertical stabilizing fin 21, and horizontal stabilizing fin 22. Lateral directional control and vertical directional control are effected through manipulation of the vertical rudder 19 and the elevator flaps 20 respectively.

The landing gear or under-carriage is designated as 23. It will be hereinafter more particularly described. To minimize resistance the motor units 13 and 15 are separately inclosed in streamlined hoods or nacelles.

As above pointed out the weight of the motor units per h. p. should be minimized and reduced to at least 2 lbs. Otherwise operation of the craft as a helicopter would be impossible. With the weight of the motor units thus reduced and the pitch of the propellers designed as indicated sufficient vertical lift can be realized to lift the machine bodily up in the air. Flight may be started

under such conditions by simply tilting the nose end of the machine upwardly Canard style, in which event, although the climb or vertical lift be relatively slow, both directional control and lateral balance are effected through the usual manipulation of the various controls.

If vertical lift is desired in starting without changing the flying attitude of the machine, i. e. with the longitudinal axis of the fuselage extending horizontally; this may be done by nullifying the thrust value until sufficient lift is obtained through the reaction of the propeller slip stream upon the aeroplane wings to bodily lift the machine into the air. Any suitable means may be provided for obtaining this nullifying effect. Furthermore, when flown as a helicopter, a hovering action is obtainable by simply throttling the motors to such an extent that the lift value of the propellers equalizes the action of gravity.

If desired a single motor unit may be substituted for the three disclosed. If the machine is thus equipped the single motor unit should be located inside the fuselage and connected up with driving shafts which extend out right and left from the motor for suitable driving connection with propellers located respectively at opposite sides of the motor. In effect this arrangement is equivalent of the multiple power plant arrangement herein illustrated. The total weight of the craft however may in this way be reduced.

Preferably all parts of the machine are streamlined, and where possible, lightened to a maximum degree. In actual flight a machine constructed as herein set forth may fly alternately as a heavier-than-air flying machine and helicopter. With the motors developing maximum power stalling in mid air is impossible, for as the machine is swung into an acute angle to the vertical the thrust value of the propellers is such that a direct vertical climb rather than a falling back, as heretofore, results.

As intimated, in a Canard type machine the tail unit is forwardly located. Herein I have illustrated directional control surfaces placed both forwardly of and aft of the tractor propellers. In either case the fuselage or nacelle terminates just behind the pilot's seat to allow the lift of the horizontal rudder to point the nose end of the machine substantially vertically without ground interference.

A machine thus characterized may be launched into the air by elevating its nose end. In fact the launching of a machine of this type in the manner stated may be readily accomplished because of the fact that its center of gravity is well toward the rear and it may therefore be provided

with a launching and landing skid of a construction enabling the machine to be rocked back without undue effort. The skid arrangement illustrated extends from a point 5 well forward to a point well to the rear of the transverse vertical plane of the center of gravity. Toward its rear end the skid is curved upwardly and rearwardly, the center of longitudinal curvature being located substantially at the center of gravity of the machine. By constructing the skids in the manner stated little effort is required to tilt it back until its nose end points substantially vertically. Of course the skid, 15 or rather its longitudinal curvature need not be described from a point coincident with the center of gravity although it is preferred that the skid be so constructed. Moreover, a skid of the type mentioned is 20 not necessarily limited in its application to machines of the Canard type. The conventional airplane may be provided with a skid of this character although in all probability the machine could not be tilted upwardly to the same extent. In launching 25 the machine illustrated in Figs. 7 and 8 the entire machine is rocked back until its nose end points vertically or nearly so. Being thus positioned it would readily take to the 30 air without any preliminary run whatsoever. If the nose end be elevated to a lesser degree the preliminary run, while not completely eliminated would be minimized due to the fact that after a very short run the 35 machine would rise in the air.

The landing gear *per se* comprises a skid 44 which extends from a point in advance of the transverse vertical plane of the center of gravity rearwardly to a point considerably aft thereof. Its curvature ahead of 40 the transverse vertical plane of the center of gravity is immaterial, although preferably of a curvature similar to that illustrated. Its curvature aft of the center of 45 gravity however is of considerable importance in that by describing the arcuate line of the skid 44 about a center coincident to the center of gravity the ease of rocking or tilting action is enhanced. If the curved 50 extensions of the skids be too far removed back of the center of gravity a considerable effort would be required to nose the machine up as its launching without a preliminary run requires.

55 As in the conventional type of machine the control surfaces of the Canard machine are all in the propeller slip stream. In Fig. 3, wherein a somewhat different character of machine is illustrated, the tractor screws 60 or propellers 50 are located behind the tail unit 51 so that the air stream entering the propellers is utilized rather than the slip stream flowing back. The principle in either instance is identical. As for the tail skid, 65 in Fig. 3 it will be noted that it too is

curved back and up although to a lesser extent than shown in Fig. 1. Again however, the principle of launching is the same as both types of machine can be rocked back sufficiently to nose the end of the machine 70 almost if not quite straight up in the air.

By "slip stream" as used in the specification and claims is meant both the entering and exit stream of air passing through the propeller or propellers. 75

What is claimed is:

1. In an aeroplane in which the control surfaces lie in the propeller slip stream, a landing gear comprising skids having their centers of longitudinal curvature located 80 substantially at the center of gravity of the machine whereby the airplane can be rocked backwardly toward a vertical position under the action of said control surfaces.

2. A landing gear for airplanes comprising skids having their center of longitudinal curvature located substantially at the center 85 of gravity of the machine.

3. In combination, an airplane having its control surfaces bathed by the propeller slip 90 stream together with a rearwardly and upwardly inclined landing gear so situated that the action of the slip stream on the control surfaces may rock the machine backward to a substantially vertical position. 95

4. In an aircraft, the combination of a body, a supporting surface, control surfaces, a propelling power plant including a propeller having an axis of rotation parallel with the longitudinal axis of the body, the 100 relative arrangement of the propeller to the supporting surface and the control surfaces being such that the slip stream of the former is directed over both the supporting surface and the control surfaces, and a landing gear 105 for the craft extended rearwardly beyond the trailing edge of the supporting surface to support the machine in starting and landing whether or not the body is substantially horizontal or substantially vertical. 110

5. In an airplane, a propelling power plant including a propeller, a control surface mounted in the propeller slip stream and distantly removed from the transverse vertical plane of the center of gravity, a 115 landing gear having a longitudinal curvature in which the center of the curvature is substantially coincident with the center of gravity, the relation of landing gear to the control surfaces being such that the action 120 of the slip stream on the control surface will rock the machine fore and aft toward a vertical position.

6. In an aircraft, the combination of a body, a supporting surface, control surfaces, 125 a propelling power plant including a propeller having an axis of rotation substantially parallel with the longitudinal axis of the body, the relative arrangement of the propeller, supporting surface and control 130

surfaces being such that the propeller slip stream is directed against the supporting surface and the control surfaces under all operating conditions, and a landing gear mounted beneath the body and extended ahead of the transverse vertical plane of the center of gravity of the craft and also to the rear thereof, that portion of the landing gear extended to the rear of the center of gravity constituting a support for the ma-

chine in starting and landing with the body substantially vertical, and that portion of the landing gear extended ahead of the center of gravity of the craft constituting a support for the machine in starting and landing with the body substantially horizontal.

In testimony whereof I hereunto affix my signature.

ALBERT F. ZAHM

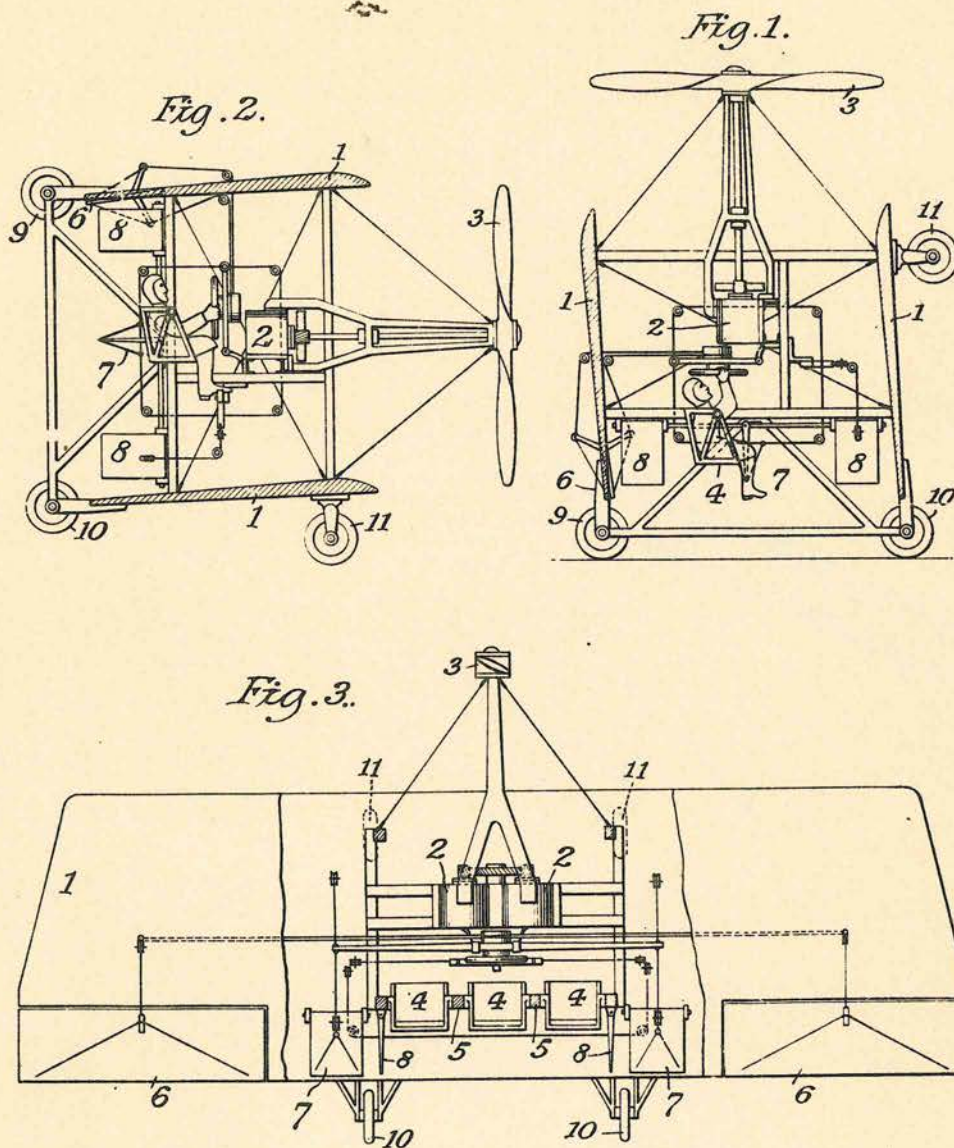
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N. TESLA

1,655,113

METHOD OF AERIAL TRANSPORTATION

Filed Sept. 9, 1921



Nikola Tesla INVENTOR
BY *Rev. Mr. Cooper & Hayward* ATTORNEYS

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF AERIAL TRANSPORTATION.

Application filed September 9, 1921, Serial No. 499,519, and in Great Britain April 1, 1921.

The utility of the aeroplane as a means of transport is materially lessened and its commercial introduction greatly hampered owing to the inherent inability of the mechanism to readily rise and alight, which is an unavoidable consequence of the fact that the required lifting force can only be produced by a more or less rapid translatory movement of the planes or foils. In actual experience the minimum speed for ascension and landing is a considerable fraction of that in full flight, and the principles of design do not admit of a very great advance in this respect without sacrifice of some desirable feature. For this reason planes of very large area, high lift wing-sections, deflectors of the slip-stream of the propeller, or analogous means, which might be helpful in these operations, do not afford the remedy sought. This indispensable high velocity, imperilling life and property, makes it necessary to equip the machine with special appliances and provide suitable facilities at the terminals of the route, all of which entail numerous drawbacks and difficulties of a serious nature. So imperative has it become to devise some plan of doing away with these limitations of the aeroplane that the consensus of expert opinion characterizes the problem as one of the most pressing and important and its practical solution is eagerly awaited by those engaged in the development of the art, as well as the general public.

Many attempts have been made to this end, mostly based on the use of independent devices for the express purpose of facilitating and insuring the start and finish of the aerial journey, but the operativeness of the arrangements proposed is not conclusively demonstrated and, besides, they are objectionable, constructively or otherwise, to such an extent that builders of commercial apparatus have so far not considered them of sufficient value to depart from present practice.

More recently, professional attention has been turned to the helicopter which is devoid of planes as distinct organs of support and, presumably, enables both vertical and horizontal propulsion to be satisfactorily accomplished through the instrumentality of the propeller alone. However, although this idea is quite old and not a few experts have endeavored to carry it out in various ways,

no success has as yet been achieved. Evidently, this is due to the inadequacy of the engines employed and, perhaps, also to certain heretofore unsuspected characteristics of the device and fallacies in the accepted theory of its operation, an elucidation of which is deemed necessary for the clear understanding of the subject.

The prospects of a flying machine of this kind appear at first attractive, primarily because it makes possible the carrying of great loads with a relatively small expenditure of energy. This follows directly from the fundamental laws of fluid propulsion, laid down by W. T. M. Rankine more than fifty years ago, in conformity with which the thrust is equal to the integral sum of the products of the masses and velocities of the projected air particles; symbolically expressed,

$$T = \Sigma(mv).$$

On the other hand, the kinetic energy of the air set in motion is

$$E = \Sigma\left(\frac{1}{2}mv^2\right).$$

From these equations it is evident that a great thrust can be obtained with a comparatively small amount of power simply by increasing the aggregate mass of the particles and reducing their velocities. Taking a special case for illustration, if the thrust under given conditions be ten pounds per horse-power, then a hundredfold increase of the mass of air, accompanied by a reduction of its effective velocity to one-tenth, would produce a force of one hundred pounds per horsepower. But the seemingly great gain thus secured is of little significance in aviation, for the reason that a high speed of travel is generally an essential requirement which can not be fulfilled except by propelling the air at high velocity, and that obviously implies a relatively small thrust.

Another quality commonly attributed to the helicopter is great stability, this being, apparently, a logical inference judging from the location of the centers of gravity and pressure. It will be found, though, that contrary to this prevailing opinion the device, while moving in any direction other than up or down, is in an equilibrium easily disturbed and has, moreover, a pronounced

tendency to oscillate. It is true, of course, that when the axis of the propeller is vertical and the ambient air quiescent the machine is stable to a degree, but if it is tilted even slightly, or if the medium becomes agitated, such is no longer the case.

In explanation of this and other peculiarities, assume the helicopter poised in still air at a certain height, the axial thrust T just equalling the weight, and let the axis of the propeller be inclined to form an angle α with the horizontal. The change to the new position will have a twofold effect: The vertical thrust will be diminished to

$$T_v = T \sin \alpha,$$

and at the same time there will be produced a horizontal thrust

$$T_h = T \cos \alpha.$$

Under the action of the unbalanced force of gravity the machine will now fall along a curve to a level below and if the inclination of the propeller as well as its speed of rotation remain unaltered during the descent, the forces T , T_v and T_h will continuously increase in proportion to the density of the air until the vertical component T_v of the axial thrust T becomes equal to the gravitational attraction. The extent of the drop will be governed by the inclination of the propeller axis and for a given angle it will be, theoretically, the same no matter at what altitude the events take place. To get an idea of its magnitude suppose the elevations of the upper and lower strata measured from sea level be h_1 and h_2 , respectively, d_1 and d_2 the corresponding air densities and $H = 26700$ feet the height of the "uniform atmosphere," then as a consequence of Boyle's law the relation will exist

$$h_1 - h_2 = H \log_{ed} \frac{d_2}{d_1}.$$

It is evident that

$$\frac{T_v}{T} = \frac{T \sin \alpha}{T} = \frac{1}{\sin \alpha} \text{ must be equal to } \frac{d_2}{d_1}$$

in order that the vertical component of the axial thrust in the lower stratum should just support the weight. Hence

$$h_1 - h_2 = H \log_{ed} \frac{1}{\sin \alpha}.$$

Taking, in a special case, the angle $\alpha = 60^\circ$, then

$$\frac{1}{\sin \alpha} = \frac{1}{0.866} = 1.1547$$

and

$$h_1 - h_2 = 26700 \times \log_{ed} 1.1547 = 3840 \text{ feet.}$$

In reality the drop will be much greater for the machine, upon reaching the lower layer with a high velocity relative to the

medium, will be urged further down along the curved path and the kinetic energy, in the vertical sense, possessed by the moving mass must be annihilated before the fall is arrested in a still denser air stratum. At this point the upward thrust will be far in excess of the opposed pull of the weight and the apparatus will rise with first increasing and then diminishing speed to a height which may approximate the original. From there it will again fall and so on, these operations being repeated during the forward flight, the up and down excursions from the main horizontal line gradually diminishing in magnitude. After a lapse of time, determined by numerous influences, the excursions should cease altogether and the path described become rectilinear. But this is next to impossible as can be readily shown by pointing out another curious feature of the helicopter.

In the foregoing the axis of the propeller was supposed to move always parallel to itself, which result might be accomplished by the use of an adjustable aileron. In this connection it may be pointed out, however, that such a device will not act in the manner of a rudder, coming into full play at intervals only and performing its functions economically, but will steadily absorb energy, thus occasioning a considerable waste of motive power and adding another to the many disadvantages of the helicopter.

Let now the machine be possessed of a certain degree of freedom, as will be the case normally, and observe in the first place that the blades of the propeller themselves constitute planes developing a reaction thrust, the pressure on the lower leading blade being greater than that exerted on the higher one owing to the compression of the air by the body of the machine and increased density in that region. This thrust, tending to diminish the angle α , will obviously vary during one revolution, being maximum in a position when the line of symmetry of the two propeller blades and that of flight are in a vertical plane and minimum at right angles to it. Nevertheless, when the horizontal speed is great it may be considerable and sufficient to quickly overcome the inertia and gyroscopic resistances all the more readily as the upper blade, which is situated in a region where the conditions are more nearly normal, operates to the same effect. Moreover, this disturbing effect partakes of the regenerative quality, the force increasing as the angle diminishes up to a maximum for $\alpha = 45^\circ$. As the axis is tilted more and more, the vertical sustaining effort of the propeller will correspondingly diminish and the machine will fall with a rapidly increasing velocity, finally exceeding the horizontal when the reaction of the blades will be directed upward so as to increase the angle

α and thereby cause the machine to soar higher. Thus periodic oscillations, accompanied by ascents and descents, will be set up which may well be magnified to an extent
5 such as to bring about a complete overturn and plunge to earth.

It is held by some experts that the helicopter, because of its smaller body resistance, would be capable of a higher speed
10 than the aeroplane. But this is an erroneous conclusion, contrary to the laws of propulsion. It must be borne in mind that in the former type, the motive power being the same, a greater mass of air must be set
15 in motion with a velocity smaller than in the latter, consequently it must be inferior in speed. But even if the air were propelled in the direction of the axis of the screw with the same speed V in both of
20 them, while the aeroplane can approximate the same, the helicopter could never exceed the horizontal component $V \cos \alpha$. To be explicit, imagine that the air current flowing with the velocity V along the
25 propeller axis inclined to form an angle α with the horizontal, be replaced by two streams one vertical and the other horizontal of velocities respectively equal to $V \sin \alpha$ and $V \cos \alpha$, it will be evident that a
30 helicopter in its forward flight could only approximate and never equal the speed $V \cos \alpha$ of the horizontal air current no matter how much the resistance be reduced for, according to a fundamental law of propul-
35 sion, the thrust would be nil at that velocity. The highest efficiency should be obtained with the machine proceeding at the rate $\frac{1}{2} V \cos \alpha$ but the most economical utilization of power would be effected when
40 $\alpha = 45^\circ$ in which case the speeds of both the horizontal and vertical streams will be $0.7 V$. From this it may be inferred that, theoretically, the best performance might be secured in propelling the helicopter forward
45 with a speed more or less approximating $0.35 V$ but the results attained in practice will be necessarily much inferior because without special provisions such as are herein set forth the device, as pointed
50 out above, would plunge down and shoot up in succession, at the same time executing smaller oscillations, which motions will retard its flight and consume a considerable portion of the motive energy all the more
55 so as the losses incident to the controlling means will be correspondingly increased.

Another very serious defect of this kind of flying machine, from the practical point of view, is found in its inability of supporting
60 itself in the air in case of failure of the motor, the projected area of the propeller blades being inadequate for reducing the speed of the fall sufficiently to avoid disaster, and this is an almost fatal impediment
65 to its commercial use.

From the preceding facts, which are ignored in the technical publications on the subject, it will be clear that the successful solution of the problem is in a different
70 direction.

My invention meets the present necessity in a simple manner without radical departure in construction and sacrifice of valuable features, incidentally securing advantages which should prove very beneficial
75 in the further development of the art. Broadly expressed, it consists in a novel method of transporting bodies through the air according to which the machine is raised and lowered solely by the propeller and
80 sustained in lateral flight by planes. To accomplish this a light and powerful prime-mover is necessary and as particularly suited for the purpose I employ, preferably, a turbine of the kind described in my U. S. Patent No. 1,061,206, of May 6, 1913, which
85 not only fulfills these requirements, but is especially adapted to operation at high temperature. I also make arrangements whereby the flying machine may be, automatically or at will of the operator, caused to function either as a helicopter or an
90 aeroplane.

Full knowledge of these improvements will be readily gained by reference to the accompanying drawings in which Fig. 1 illustrates the machine in the starting or landing position and Fig. 2, in horizontal flight. Fig. 3 is a plan view of the same with the
95 upper plane partly broken away.

The structure is composed of two planes or foils 1, 1 rigidly joined. Their length and distance apart may be such as to form a near-square for the sake of smallness and compactness. With the same object the tail is
100 omitted or, if used, it is retractable. The motors 2, 2 in this case turbines of the kind described in my patent before referred to, and other parts of the motive apparatus are placed with due regard to the centers of gravity and pressure and the usual controlling means are provided. In addition to these
105 any of the known stabilizing devices may be embodied in the machine. At rest the planes are vertical, or nearly so, and likewise the shaft driving the propeller 3, which is constructed of a strength, size and pitch that will enable it to raise the entire weight with the motors running at an even greater rate than when propelling the machine horizontally. Power is transmitted to the shaft from the turbines through suitable gears. The seats 4, 4, 4 for the operator and passengers are suspended on trunnions
110 5, 5 on which they can turn through an angle of about 90° , springs and cushions (not shown) being employed to insure and limit their motion through this angle. The usual devices for lateral and directional control, 6, 6 7, 7 and 8, 8 are pro-
115 120 125 130

vided with mechanical connections enabling
 the operator to actuate the devices by hand
 or foot from his seat in any position. At the
 start, sufficient power being turned on by
 5 suitable means, also within his reach, the
 machine rises vertically in the air to the
 desired height when it is gradually tilted
 by manipulating the elevator devices and
 proceeds like an aeroplane, the load being
 10 transferred from the propeller to the foils
 as the angle of inclination diminishes and
 the speed in horizontal direction increases.
 From the foregoing it will be understood
 that, simultaneously with the tilting of the
 15 machine, the operator will increase the
 thrust of the propeller in order to compensate
 for the reduction of sustaining force which
 follows inevitably from the diminution of
 angle α and before the reaction of the
 20 planes can come into full effect. He will
 thus prevent a downward plunge and the
 production of dangerous oscillations which
 have been dwelt upon above, and by suitable
 manipulation of the apparatus and gradual
 25 cutting down of the power developed by
 the prime mover, as forward velocity is gained
 and the planes take up the load, he may
 cause the machine to advance horizontally
 along a sensibly straight line, a condition
 30 essential to the attainment of the best practical
 results. In descending, the forward
 speed is reduced and the machine righted
 again, acting as a helicopter with the propeller
 supporting all the load. Obviously,
 35 as the device is slowed down and righted
 causing the planes to lose part or all of their
 sustaining efforts, the operator will apply
 more power to the propeller increasing
 thereby the thrust to the required magnitude
 40 and in all such operations of starting and
 loading as well as tilting for regulating the
 height, meeting the air conditions or for other
 purposes it will be his object to modify
 the propeller thrust in about the same measure
 45 as the varying reaction of the planes
 may demand in order that the lifting force
 be sensibly constant. Evidently also, whenever
 necessary or desirable, power far in excess
 of that normally required may be applied
 50 during the flight and the machine
 propelled at a greatly increased speed. The
 type of turbine used is a motor of great
 lightness and activity and lends itself exceptionally
 to this kind of work for which ordinary
 55 aviation motors are unsuited. It is
 capable of carrying a great overload and
 running without danger at excessive speed
 so that during the starting and landing operations
 the necessary power can be developed
 60 by the motors even though less efficiently
 than under their normal working conditions.
 Special means of control may be provided,
 if necessary, for increasing the power supply
 in these operations. Owing to its extreme
 65 simplicity the motive apparatus is very reli-

able in operation, but should the power give
 out accidentally, landing can still be easily
 effected by volplaning. For this purpose,
 in addition to wheels 9, 9 and 10, 10 wheels
 11, 11 are employed, the latter being mounted
 70 on the forward end under the lower plane
 and so that when the machine rests on level
 ground the propeller shaft will have the
 desired inclination which is deemed best
 for rising in the manner of an aeroplane. 75
 Such an aeroplane constructed and operated
 as described, unites the advantages of both
 types and seems to meet best the requirements
 of a small, compact, exceedingly
 80 speedy and yet very safe machine for commercial
 use. Especially good practical results
 are obtainable by the use of my turbine
 which can be depended upon to develop the
 necessary energy for lifting, even if it should
 85 be considerably greater than that consumed
 in flight under normal conditions. This end
 can be conveniently attained by temporarily
 supplying more of the working fluid to the
 rotor and driving it faster, or running it at
 90 about the same speed and increasing the effort
 by adjustment of the pitch of the propeller,
 or other means known in the art. The latter
 should be designed to work most economically
 during the flight, as its efficiency in the
 95 starting and landing operations is of relatively
 small importance. Instead of a single large
 screw as described a number of smaller ones
 may be used, in which case gearing can be
 dispensed with. The biplane seems to be best
 100 suited for the chief purpose contemplated but
 the invention is applicable to monoplanes and
 other types.

To sum up, the helicopter type of flying
 machine, especially with large inclination
 angle of the propeller axis to the horizontal,
 105 at which it is generally expected to operate,
 is quite unsuitable for speedy aerial transport;
 it is incapable of proceeding horizontally
 along a straight line under the prevailing
 air conditions; it is subject to dangerous
 110 plunges and oscillations and, what is most
 important from the commercial and practical
 point of view, it is almost certainly
 doomed to destruction in case the motive
 power gives out. These drawbacks and defects
 115 are overcome by the methods and apparatus
 I have described through which a novel type
 of flying machine may be realized possessing
 all the advantages of the helicopter being
 at the same time safe and capable
 120 of a speed equal to or even greatly exceeding
 that of the present aeroplane.

To my knowledge various forms of aeroplanes
 have been proposed with the object of
 attaining similar results but a careful
 125 study shows that none of them is capable
 of the actions as those here contemplated for
 want of proper methods of operation as well
 as suitable apparatus.

I do not claim herein the apparatus by 130

means of which this method is or may be carried out either in the special form illustrated or in modifications of the same, as this is the subject of a separate application.

5 What I desire to secure by Letters Patent is:

1. The hereinbefore described method of aeroplane transportation which consists in developing by the propelling device a vertical thrust in excess of the normal, causing thereby the machine to rise in an approximately vertical direction, tilting it and simultaneously increasing the power of the motor and thereby the propeller thrust, then
10 gradually reducing the power and thrust as forward speed is gained and the planes take up the load, thus maintaining the lifting force sensibly constant during flight, tilting the machine back to its original position and
15 at the same time increasing the power of the motor and thrust of the propeller and effecting a landing under the restraining action of the same.

2. The method of operating a helicopter
25 which consists in varying the power of the motor and thereby the thrust of the propeller

according to the changes of inclination of its axis, so as to maintain the lifting force sensibly constant during the forward flight.

3. The above described method of transporting from place to place a heavier than
30 air flying machine, which consists in applying power to the propeller while its axis is in a vertical position sufficient to cause the machine to rise, tilting it and at the same
35 time applying more power to increase the thrust, then gradually diminishing the power as the load is transferred from the propeller to the planes, tilting back the machine and so controlling the applied power as to
40 effect a slow descent upon the landing place under the restraining action of the propeller.

4. In the transport of bodies by aeroplane, the method of controlling the propeller thrust and reaction of the planes by varying
45 the power of the motor correspondingly with the inclination of the machine so as to maintain the lifting force sensibly constant during the forward flight.

In testimony whereof I hereto affix my
50 signature.

NIKOLA TESLA.